ARTIFICIAL NEURAL NETWORK (ANN) BASED DECISION SUPPORT MODEL FOR ALTERNATIVE WORKPLACE ARRANGEMENTS (AWA): READINESS ASSESSMENT AND TYPE SELECTION

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ARTIFICIAL NEURAL NETWORK (ANN) BASED DECISION SUPPORT MODEL

FOR ALTERNATIVE WORKPLACE ARRANGEMENTS (AWA):

READINESS ASSESSMENT AND TYPE SELECTION

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DEDICATION

This dissertation is sincerely dedicated to:

My respected father, Hwasung Kim and my lovely mother, Jungsoon Cho, who have always trusted and supported me in tremendous ways. They have instilled in me the belief that intellectual belief is the highest calling, and that belief does have the power to change people's lives.

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SUMMARY

A growing body of evidence shows that globalization and advances in information and communication technology (ICT) have prompted a revolution in the way work is produced. One of the most notable changes is the establishment of the alternative workplace arrangement (AWA), in which workers have more freedom in their work hours and workplaces. As more and more businesses have begun to adopt AWA, the number of employees who are working away from a permanently assigned office space and those who are geographically and virtually distributed has been increasing throughout the world (Venezia et al., 2007).

Just as all organizations are not good candidates for AWA adoption, all work types, all employees and all levels of facilities supports are not good candidates for AWA adoption and responding to the needs of rapidly a changing business environment, many different forms of alternative workplaces have been created and adopted: on-site workplaces such as free address, hoteling and group address and off-site workplaces such as telecommuting, satellite office and so on.

The main problem is that decision makers have no established tools to assess their readiness for AWA adoption or to select among the possible choices regarding which AWA type is most appropriate considering their organizations' business reasons or objectives of adoption and the current readiness levels.

The goal of this dissertation is to provide an understanding of the assessment of the initial readiness for AWA adoption and to develop a decision support model which can predict an appropriate AWA type and satisfaction level to assist the process of decision-making for AWA adoption from an organizational perspective. The specific objectives are: 1) To develop Readiness Level Assessment Indicators (RLAI) for assessing the extent of an organization's readiness for the adoption of an AWA. RLAIs

can be used to predict the potential successfulness of AWA adoption from an organizational perspective and 2) Based on actual AWA adoption cases from high-tech companies, to develop an AWA decision model that allows decision makers to select an appropriate AWA type and predict the satisfaction level.

The hypothesis of this dissertation is that:

A positive rank correlation exists between organizational readiness level for AWA adoption and organization's satisfaction with AWA.

(Independent variables which can be used for measuring an organization's readiness level for AWA adoption and dependent variable which can be used for measuring the organization's satisfaction with AWA are described in detail in Chapter 4).

An extensive review of literature on a wide range of AWA issues is presented, and expert surveys are conducted to identify major business reasons, significant factors and relevant attributes. The findings from the review of the literature and an evaluation from the expert panel are combined to finalize the assessment indicators for developing RLAI. A total of 64 real adoption cases have been collected using RLAI from high-tech companies that have already adopted any of six AWA types: Hoteling, group address, shared office, satellite office, home office, and virtual office.

The predictive data mining techniques are reviewed since the main goal of predictive data mining is to identify a statistical or artificial neural network (ANN) model that can be used to predict the outcomes in business. Regression technique is abandoned for developing decision model because it is not very useful for small data samples, and it performs better for the output variables containing continuous data.

Additionally, two outputs, type selection (Y1) and satisfaction level (Y2) can not be investigated at the same time using the regression technique. The artificial neural network (ANN) technique is selected to develop a decision model, and the ANN-based decision model reliably suggests an AWA type and an anticipated satisfaction level given the objectives and the readiness level of high-tech companies. As for the first ANN model validation, predictive performance of the ANN model is evaluated by comparing the predicted outputs and the actual outputs in the testing sets. Additionally, as for the second validation, this research also adopts a case-based reasoning (CBR) technique to develop the second decision model. Predictive performances of the two decision models are compared. Consequently, it is validated that the ANN model is more effective and robust in predictive performance than the CBR model is.

This research resulted in the development of readiness level assessment indicators (RLAI), which measure the initial readiness of high-tech companies for adopting AWAs and the ANN based decision model, which allows decision makers to predict not only an appropriate AWA type, but also an anticipated satisfaction level considering the objectives and the current readiness level. This research has identified significant factors and relative attributes for decision makers to consider when measuring their organization's readiness for AWA adoption. Robust predictive performance of the ANN model shows that the main factors or key determinants have been correctly identified in RLAI and can be used to predict an appropriate AWA type as well as a high-tech company's satisfaction level regarding the AWA adoption.

In future research, it will be necessary to extend the scope to the next implementation stage, where a detailed feasibility study including cost estimation and risk analysis for the final adoption decision is conducted. More efforts could be researched to develop a decision support system which can provide more accurate and solid predictions on AWA adoption decision issues as well as measure the performance of distributed workers.

CHAPTER 1

INTRODUCTION

1.1 Introduction

A Telework Trendlines 2009 report notes an increase in the number of Americans who work at home or at workplaces other than the central office, including satellite offices and virtual offices, at least one day per month from 28.7 million in 2006 to 33.7 million in 2008 (Johnson, 2009). Nemertes' benchmark study of 2007 reports that 83% of the participating organizations consider their workplace structure as virtual ,where 91% of the participating organizations' employees work outside of headquarters and about 96% of them utilize some forms of real-time collaboration tools such as Web conferencing, instant messaging and video conferencing.

Many researchers use the term alternative workplace arrangements (AWA) loosely and interchangeably with other terms. Alternative workplace arrangements(AWA), flexible workplace arrangements (FWA), distributed workplace arrangements (DWA), remote workplace arrangements (RWA), telecommuting arrangements and teleworking arrangements are all similar terms implying a workplace arrangements, aided by ICT, where employees do not have permanently assigned workspaces on company premises. The author united all similar terms into alternative workplace arrangements (AWA) and refers to employees working under an AWA setting as distributed workers in this research. AWAs are typically described as various workplace settings in which workers do not have a permanent workspace on an organization's premises. These consist of many types of alternative workplace settings rather than traditional workplace at an assigned workstation in the organization's main office. The definition of AWA for this research is any workplace arrangements enabled by ICT that allow employees to work on or off-site.

1.2 Background

Real estate costs, air pollution, and traffic congestion resulting from mass commuting have worsened while companies seek to retain talented, knowledgeable workers in order to remain competitive (Roper and Kim, 2007). Adopters of AWA have reported clear benefits such as reduced operating costs by space savings (Higa and Shin 2003; Cascio, 2000) improved productivity, retention of skilled knowledge workers (Gordon, 1988; Kurland and Bailey, 1999), reduced turnover and absenteeism (Kurland and Bailey, 1999), improved customer satisfaction (Peters et al., 2004), reduced traffic congestion and environmental impacts(Belanger and Collins, 1998), improved employees' work-life balance(Belanger and Collins, 1998; Cascio, 2000), higher profits, and access to global market (Cascio, 2000).

Thus, the trend of AWA is likely to continue in the future, leading to greater reductions in the traditional ratio of workers to workspace, particularly in large companies. To successfully respond to the various demands of the competitive business environment (Martinez-Sanchez et. al., 2008) and to adapt to the growth of AWA, such organizations are moving away from their physical headquarters and entering larger networks across cities and countries. All of these changes have forced them to reevaluate their goals and find solutions to the challenges they face by adopting AWA, ICTs, and other workplace practices (Harrisoin and Steggles, 2005; Roper and Kim, 2007).

The rapid rate of business pattern change impacts the workplace. As organizational practices evolve, the workplace is typically unable to adapt as quickly as needed. Thus, what is now needed is a way to provide assistance for decision makers who wish to assess their readiness for AWAs and select among the possible choices which AWA type is most appropriate given their objectives of adoption and current readiness conditions.

Much scholarly work has been done on the topic of AWAs, especially on the significant factors and characteristics to be considered for AWA adoption. Venkatesh and Vitalari (1992) have provided three factors in a conceptual model for AWA study: organization/work, ICT, and household, including worker's characteristics. All three independent variables are related to a fourth factor, supplemental work at home, which is the dependent variable in their study. Characteristics surrounding AWA are organizational, individual, work, household and technology characteristics (Belanger and Collins, 1998), and the AWA environments are separated into four components: social environment, technical environment, resource environment, and organizational structure environment (Swan et al., 2004).

For AWA adoption to be successful, it is important that the work process be easily transformable into AWA, that ICT is available, that the organizational culture be oriented towards evaluating work results than process, and that autonomy be promoted (Clear and Dickson, 2005). Numerous studies have attempted to find solutions for AWA adoption issues. For determining the suitability of AWA implementation, a framework was proposed to establish a method (Fritz et. al., 1994). Various types of AWAs are described and the suitability of each AWA types from the organizational perspective is discussed (Bui et. al., 1996). A conceptual model of intra-organizational adoption of telework at four stages: initiation, adoption, implementation and institutionalization, is depicted (Shin et al., 1997). The adoption patterns of different AWA types by different areas and the size of organizations in Japan are delineated (Higa and Wijayanayake, 2000). Five successful AWA adoption cases and four not-so-successful adoption cases in terms of the four AWA adoption phases of inception, testing, implementation and future planning are examined and compared (Higa and Shin, 2003). However, none of the decision models has shown clear evidence regarding its applicability to the AWA adoption decision process (Clark, 1998).

1.3 Problem Statement

Lyne (1995) notes that today's organizations need a comprehensive view of the whole organization in order to facilitate effective workplace decision-making, and many different forms of alternative workplaces have been created and adopted to respond to the needs of a rapidly changing business environment. It is challenging to appropriately assess the readiness of organizations to consider an AWA as a suitable option.

Even though the adoption of AWA is an organizational phenomenon, relatively few studies have addressed the organizational adoption of AWA (Shin et. al, 2000). A review of the literature reveals that there is little guidance about which organization, work types, workers and workspaces are appropriate for AWA program (Belanger and Collins, 1998), and limited research about how the decision should be made to adopt a particular type of workplace arrangement (Fritz et al., 1996). No particular decision model yet developed has shown clear evidence regarding its applicability to AWA adoption (Clark, 1998). Today's enterprises need assistance in assessing their readiness to adopt an AWA and develop a distributed workplace strategy (Harrison 2002).

Currently, decision makers have limited tools to assess their readiness for the adoption of AWA, or to select among the possible choices on which AWA type is more appropriate considering their organizations' business reasons of adoption and current readiness conditions.

1.4 Objective and Hypothesis

The goal of this dissertation is to provide an understanding of the assessment of the initial readiness for AWA adoption and to develop a decision support model which can predict an appropriate AWA type and satisfaction level to assist the process of decision-making for AWA adoption from an organizational perspective.

The specific objectives are:

1) To develop Readiness Level Assessment Indicators (RLAI) for assessing the extent of an organization's readiness for the adoption of an AWA. RLAIs can be used as to predict the potential successfulness of AWA adoption from an organizational perspective.

2) To develop an AWA decision model, one based on actual AWA adoption cases from high-tech companies that allows decision makers to select an appropriate AWA type and predict the satisfaction level.

At the outset, with particular emphasis on Roger's innovation attributes(Roger, 1995) and the Leavitt's model of organizational subsystems(Leavitt, 1965), surrounding factors and relevant attributes that can be used to assess the organizational readiness for AWA adoption were identified and selected, and based on these parameters, RLAI was developed. Using RLAI, a total of 64 AWA adoption cases were collected from high-tech companies for this research.

The hypothesis of this research is as follows:

H: A positive rank correlation exists between organizational readiness level for AWA adoption and organization's satisfaction with AWA.

Hypothesis testing is used to make a conclusion about a population using data obtained from a sample. A hypothesis is a statement that can be either proved or disproved. According to Weiss (1999), there are steps needed to hypothesis testing:

- Formulate the hypothesis
- Identify a statistical method that can be used to measure the truth of the hypothesis
- Determine the p-value and compare it to an acceptable significant value

Rank correlation analysis is conducted to measure the association between two ordinal variables: the readiness level and the satisfaction level. Once it is proved that there are some relationships existing between independent variables and dependent variables, feasible modeling techniques were reviewed. The predictive data mining techniques were selected since the main goal of predictive data mining is to identify a statistical or artificial neural network (ANN) model that can be used to predict the outcomes in business. The artificial neural network (ANN) modeling technique is adopted to develop a decision model, and the case-based reasoning (CBR) method is applied to validate the model. The results are discussed in greater detail in chapter 5.

1.5 Scope

1.5.1 Scope by Stage

The scope of this dissertation is limited to two stages as depicted in Figure 1.1: Initiation stage and Adoption stage.

- Initiation stage: AWA consideration starts and significant factors and attributes are identified during this stage
- Adoption stage: AWA initial adoption decision considering target type and expected satisfaction level is made during this stage
- Implementation stage: A detailed feasibility study including cost estimation and risk analysis is conducted followed by the final AWA adoption decision-making during this stage. This stage is outside the scope of this research.

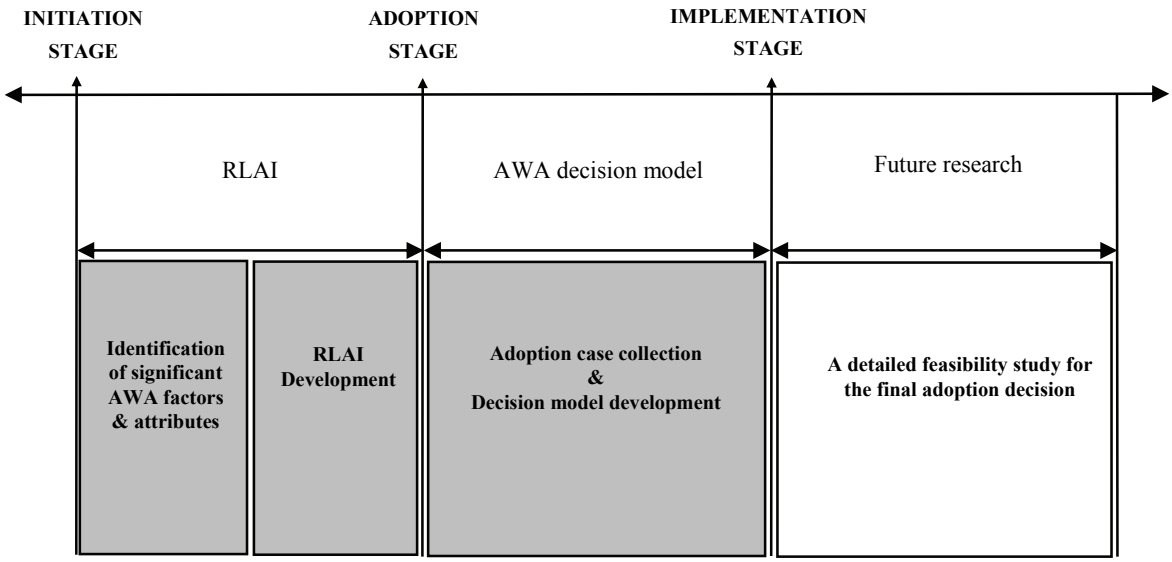


Figure 1.1 Research Scope by Stage

1.5.2 Scope by AWA Type

Higa and Shin (2003) analyzed participating organizations in their research and found more successful AWA adoptions in cases where full-time AWA was implemented. If employees work in an alternative workplace only part of the time and still retain the permanently assigned workspace at the central office, organizations expecting to reduce office space costs can not achieve their business reason of adoption.

Therefore, in exploring various types of AWAs, this dissertation is limited to only primary places for work and full-time AWAs. Other types of AWAs such as mixed type (e.g. hoteling and home office), part-time AWAs, supplemental work-at-home and self-employed workers are not examined in this research. Based on the literature review, AWAs are limited to six recurring types as follows: on-site workplaces such hoteling, group address and shared office and off-site workplaces such as satellite office, home office and virtual office.

Table 1.1 Six AWA Types Selected

Place	AWA Type
On-site	Hoteling
	Shared office
	Group address
Off-site	Satellite office
	Home office
	Virtual office

1.5.3 Scope of Target Organization

The scope of this dissertation is limited to only high-tech companies such as computer, consumer electronics, engineering, IT, networking and telecom companies.

1.6 Assumptions

This dissertation investigates significant factors and attributes useful for measuring high-tech companies' readiness for AWA adoption. There are two assumptions as follows:

- Decision makers in this dissertation are facility managers because they have the potential to promote and enhance the AWA environment and are responsible not only for the central office physical facilities but also for home office arrangements. The responsibilities of facility managers now extend beyond operational issues to the more fundamental goals of providing high performing and sustainable workplaces (Kaczmarczyk and Murtough, 2002). Facility managers are responsible for developing workplace strategies to meet the organization's current and future needs (McGregor, 2000).

- Well-prepared managerial actions dealing with challenges in AWA setting can positively influence the success of AWA

1.7 Methodology

This dissertation is intended to address and provide a better understanding of the issues of AWA - more specifically issues of AWA adoption readiness assessment and appropriate type selection. The research framework for this dissertation consists of eight tasks. The seven circles in gray represent the decision criteria associated with each task which will be explained in the following section. The following ten tasks in parentheses are illustrated in Figure 1.3:

1. Decision Criteria Establishment
2. Review of Literature
3. Expert Panel
4. Selection of Major Business Reasons, Significant Factors, Relevant Attributes, and assessment items
5. Survey Design for Panel
6. Acquiring Approval for Research with Human Subject
7. Readiness Level Assessment Indicators(RLAI) Development
8. Data Collection and Analysis
9. Decision Model Development
10. Model Testing and Validation

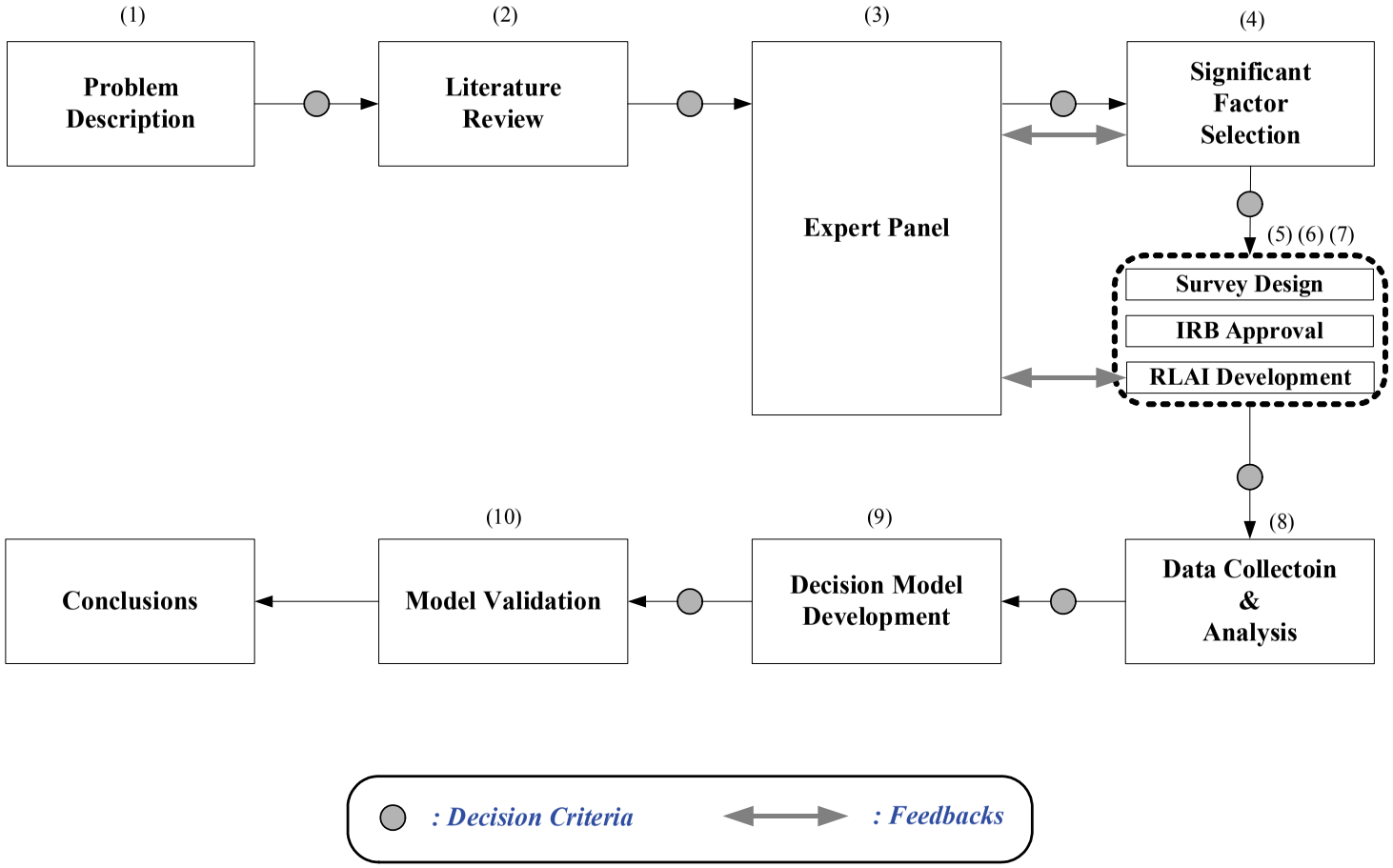


Figure 1.2 Research Methodology

1.7.1 Decision Criteria Establishment

The primary aim of this dissertation is to develop readiness level assessment indicators (RLAI) and decision model for predicting the most appropriate type of AWA and the expected satisfaction level. As a guideline and theoretical foundation, Roger's innovation attributes were adopted to identify factors and relevant attribute that can be used to develop RLAI as shown in Figure 1.1.

After identifying and finally selecting all major business reasons of AWA adoption and significant AWA factors and relevant attributes that are used as a foundation for developing assessment metrics, the RLAI is developed to help organizations assess the initial readiness for AWA adoption.

64 real AWA adoption cases were collected in the form of RLAIs to build up a decision model which would then predict appropriate types of AWAs. Establishing the decision criteria, which is a crucial step for each process, is briefly discussed in the following sections.

A. Criteria for the Literature Review

The review of literature on the subject of AWA, such as its background, various types, expected benefits, challenges, and the relative theories decision support system for AWA, has been conducted from books, peer-reviewed journals and conference proceedings in the related fields of management, information science, engineering, workplace, decision support system, architecture and real estate. At the outset, with particular emphasis on Roger's innovation attributes (Roger, 1995) and Leavitt's model of organizational subsystems (Leavitt, 1965), major business reasons, surrounding factors and relevant attributes were identified. A keyword search included alternative workplace, flexible workplace, distributed workplace, telework, telecommuting, readiness,

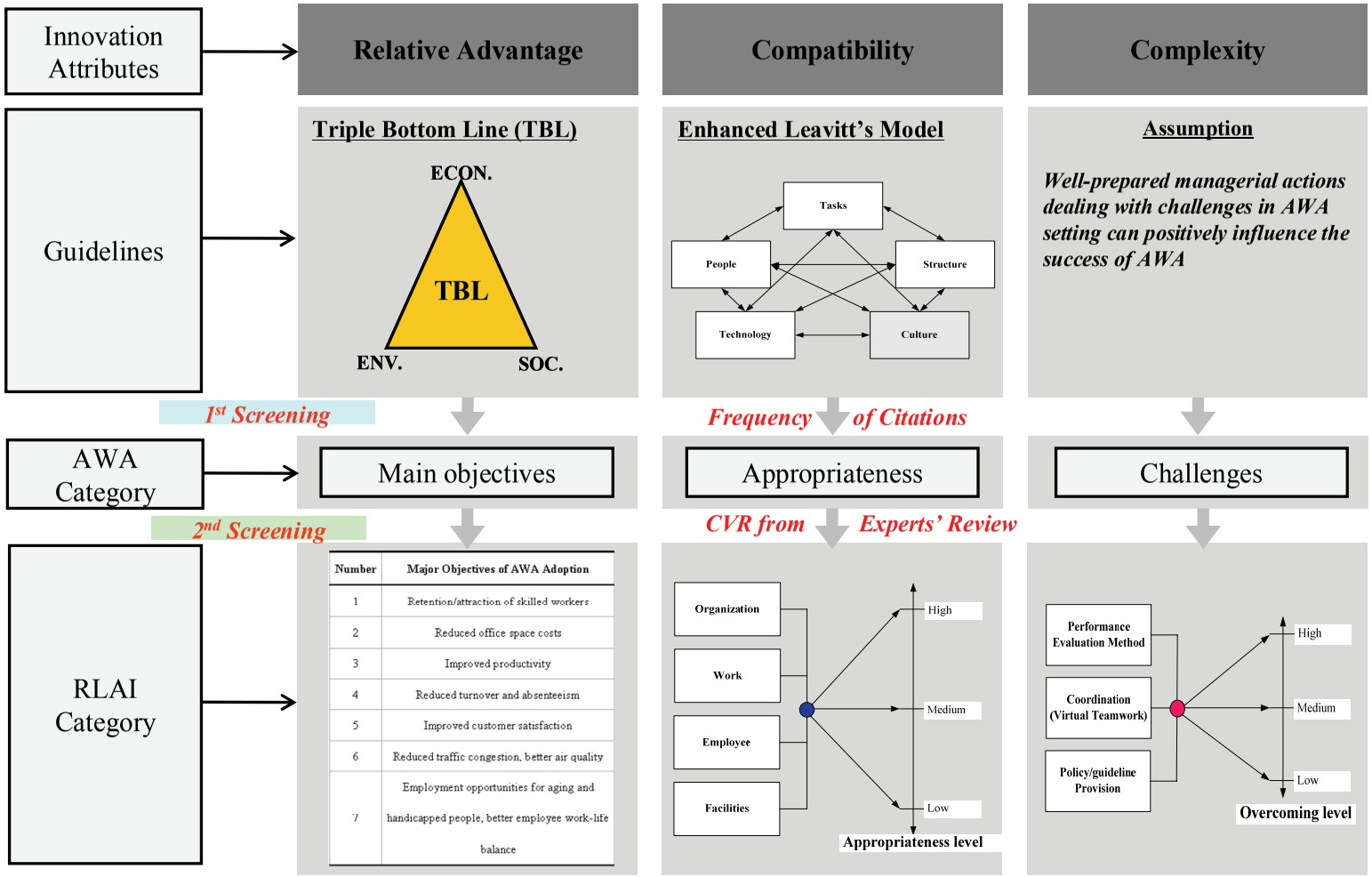


Figure 1.3 Research Framework for Developing RLAI

appropriateness, suitability and other words relevant to AWA readiness assessment and adoption decision-making. In this step, the frequency was tabulated and used as a foundation for the final selection of significant factors and relative attributes as discussed in later sections.

B. Selection Criteria for the Expert Panel

Finally, experts with practical experience and theoretical knowledge of different aspects of AWA from both industry and academia were selected for this research. The three main criteria used in identifying and selecting the experts are as follows:

1. Either practical experience with or theoretical knowledge regarding AWA readiness assessment
2. Either practical experience with or theoretical knowledge of AWA adoption decision making
3. Consent to serve and offer expert knowledge for this research

C. Selection Criteria for Major reasons, Significant Factors and Attributes

The recommendations from the expert panel and the results of the extensive review of literature are combined to finalize the factors and attributes forming the foundation of RLAI. The two major criteria for the final selection used are as follows:

1. Citation frequency
2. Experts' recommendation

D. Criteria for the Readiness Level Assessment Indicators(RLAI) Development

The assessment items for all the attributes were added to complete the RLAI. The survey questions were sent to 15 experts to have the assessment indicators of RLAI

validated. According to a three-point Likert scale ("1"= not necessary, "2"=important but not essential, "3"=essential), 15 experts were asked to rate each assessment item. The content validity ratio (CVR) method was applied to ensure the adequacy of items for the initial readiness assessment for AWA adoption. Only items with CVR values higher than 0.49 were retained and a list of 18 assessment indicators was finalized for the RLAI.

E. Criteria for Data Collection and Analysis

In order to collect data from the industry, the data collection table was prepared based on the RLAI developed in Chapter 3. Through telephone interviews, conference calls and email questionnaires, a total of 64 real adoption cases were collected using RLAI from 19 large high-tech companies that already had adopted any of the six AWA types: hoteling, group address, shared office, satellite office, home office, or virtual office. In collecting the cases, the author asked the respondents to provide cases adopted in 2005 or later. Non-parametric ranking correlation analysis methods such as Spearman and Kendall were selected to test the hypothesis of this dissertation because they measure the strength of any association between a pair of variables.

F. Criteria for the Decision Model Development

Among the various modeling techniques used in the predictive data mining, the artificial neural network (ANN) technique was selected, and the criteria for the selection are as follows:

1. The nature of data collected
2. Size of data sample
3. Ease of use
4. Correlation analysis results from data analysis
5. Simultaneous prediction capability on AWA type and satisfaction level
6. Practicality

G. Criteria for the Decision Model Testing and Validation

The validation criteria were as follows:

1. The prediction accuracy between the predicted results generated by the ANN model and the actual results
2. Comparison of prediction accuracy and percentage error (PE) between the ANN- model and the CBR model.

1.7.2 Extensive Literature Review

The problems in AWA adoption issues are that decision makers have no established tools to assess their initial readiness toward AWA and that it is difficult to select among the possible choices the AWA type that is most appropriate considering their organizations' business reasons of adoption and current readiness conditions. After identifying these two problems, this research conducted a comprehensive review of literature on a wide rage of AWA issues. The author attended seminars and workshops organized by International Facility Management Association (IFMA) and reviewed the conference proceedings as a part of this step. More than 70 articles from different fields were identified and analyzed to come up with the significant factors of AWA in general. Reviews of related journal articles, as well as internet resources presenting extensive discussions on some elements associated with the AWA readiness assessment and adoption decision topics were included in this process.

Innovation theory can serve as a foundation for decision makers to start considering adoption of AWA an organizational innovation, specifically a workplace innovation. Among these attributes, the ones found most important as far as their influence on adoptions decisions were speeding the adoption of organizational innovation, which is AWA in this research, relative advantage, compatibility and complexity. From three innovation attributes, three factors of AWA category were extracted: business

reasons, appropriateness, and challenges. The factors and attributes of each AWA category were reviewed and explained to build up foundations for the readiness level assessment indicators (RLAI). Detailed assessment items are described in Chapter 3. Significant factors and attributes were identified based on the frequency of their citations, and they were then tabulated.

1.7.3 Expert Panel

The author attended the 2008 International Facility Management Association (IFMA) Atlanta Workplace and addressed innovative workplace issues for all professionals as a speaker. During the seminar, the author had a chance to discuss AWA issues identified from the review of literature with eight innovative workplace professionals. These eight professionals are workplace industry experts who have prior experience in assessing an organization's readiness, and in making decisions of alternative workplace adoption, or working under some forms of AWA setting. The predominant business reasons for AWA, the significant factors, and the relative attributes were discussed in detail during the seminar. The author could validate the current problems of AWA readiness assessment and decision making with them and the discussions and survey answers from experts guided the author for the next steps.

The experts with practical experience and theoretical knowledge of different aspects of AWA from both the industry and academia were finally selected for this research. A total of 15 experts, including the two experts already identified at 2008 IFMA Atlanta Workplace, finally agreed to serve on the panel, which was formed to validate the major business reasons for AWA adoption and the key factors and attributes used in readiness level assessment indicators (RLAI).

1.7.4 Major Business Reasons, Factors and Attributes Selection

At the 2008 IFMA Atlanta Workplace, the first survey was distributed to eight professionals to build up a foundation for the Readiness Level Assessment Indicators (RLAI) to help organizations assess their initial readiness for AWA adoption. After conducting a comprehensive review of the literature on a wide rage of AWA issues from an organizational perspective, the author obtained feedback from the experts and attended seminars and workshops on innovative workplaces. This, along with the review of the conference proceedings allows the author to gain further insights on important parameters of AWA adoption. In this way, all the major reasons for AWA, readiness factors and attributes were finalized for the experts' review in this step as shown in Figure 1.3.

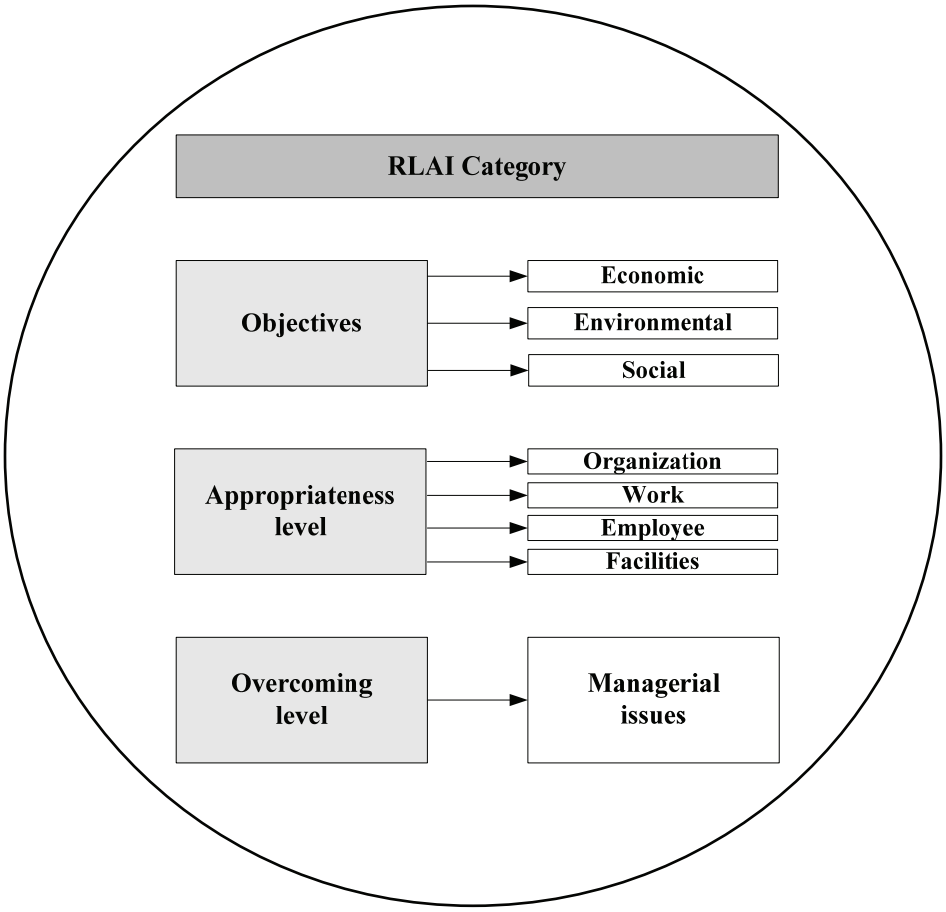


Figure 1.3 Selected Factors in RLAI Category

1.7.5 Design Survey for the Panel

The survey questions consisting of three main areas were designed to effectively get feedback from the experts. Open-ended questions were not used because the qualitative information could be reduced while coding and the answers were likely to lose their initial meaning. Thus, closed-ended questions in a three point ranking scale were used to effectively analyze the answers. Pre-testing was carried out after the initial draft survey questions were developed. The draft questions were provided to three experts to see whether the items were clear to understand. Based on feedback from the pre-testing, the author changed the wording of some items and the order to finalize the survey questions.

1.7.6 Required Approvals for Research Using Human Subjects

Human-based research requires special review and approval from the Institutional Review Board (IRB). After the required training to obtain certification was completed, the protocol of this research was submitted. The protocol, H09200, was approved by the Institutional Review Board (IRB).

1.7.7 Readiness Level Assessment Indicators (RLAI) Development

In addition to the final selections of significant factors and attributes, assessment items for each attribute were added to complete the readiness level assessment indicators (RLAI). RLAI was developed to provide decision makers with an understanding of how to assess the initial organizational readiness AWA adoption and to develop a decision model. The survey questions were designed to get RLAI validated by experts. According to a three-point liker scale (“1”= not necessary, “2”=important but not essential,

"3"=essential) each assessment item was carefully rated by the 15 experts and finally selected for this research using the content validity ratio (CVR) method to ensure the adequacy of indicators items.

The CVR, which is an item statistic, is helpful in the retention or rejection of specific items (Lewis et al., 1995). According to the CVR table published by Lawshe, a CVR of 0.49 is minimally required for each item to prove its validity for AWA readiness assessment metrics when there are 15 people on the content evaluation panel. Among all items identified from the literature review and finalized through the analysis of the results on the first survey, items with CVR values higher than 0.49 were retained, and a list of 18 assessment items was finalized for RLAI.

1.7.8 Data Collection and Data Analysis

The data collection table was tentatively prepared based on the RLAI developed in Chapter 3 to collect data from the industry. After the table was developed, pre-testing was conducted. Collection tables were sent to two companies, and the respondents were asked to fill out the collection table. Through telephone interviews, conference calls and email questionnaires, a total of 64 real adoption cases were collected, using RLAI, from 19 large high-tech companies that had already adopted at least one of the six AWA types: hoteling, group address, shared office, satellite office, home office, and virtual office.

Each high-tech company usually has many adoption cases, and the cases are documented by year. In collecting cases, the author asked the respondents to provide cases adopted in 2005 or later. Among the 64 cases collected, the number of cases documented in 2005 was three; in 2006, six; 2007, eleven; and in 2008, 22. The number of cases on-going is 22.

The data collected using RLAI were measured by either an ordinal or nominal scale. The appropriate descriptive statistics are frequencies. The type of measuring scale

used to collect data determines the type of statistical tests that can be carried out on the data.

In order to test the hypothesis, correlation analysis was selected because the correlation coefficient measures the strength of any association between a pair of variables (Ling and Liu, 2004). The Pearson correlation analysis was not selected because the assumptions for using Pearson were violated and nonparametric methods are most appropriate when the sample sizes are small (Hinton et. al., 2004). Alternatively, Spearman's *rho* and Kendall's *tau-b* were used because they perform well when one or both variables are not measured on an interval scale, when the data are not normally distributed, and when the relationship between variables is non-linear.

1.7.9 Decision Model Development

Given the criteria for model selection such as the nature of the data, the sample size, the ease of use, the correlation analysis results, the practicality and the simultaneous prediction capability for each AWA type and satisfaction level, artificial neural network, the ANN modeling technique, which has robust learning capabilities and accurate prediction ability, was selected to develop a decision model. A feedforward backpropagation network (BPN) was adopted among different types of ANN because it is one of the most important ANN paradigms and because it is reasonably simple to implement and works extremely well for a wide variety of applications. After a specific ANN architecture was designed, the collected 64 real adoption cases were randomly divided into 52 training cases and 12 test cases. The target training error was set to 0.01 which means that each record was to be within 0.01 of the actual value. The training was stopped when the average training error dropped below the target error (0.008). However, all the cases were successfully trained. After the training stopped, a reserved data set consisting of 12 cases, called a testing or validating set, was entered into the ANN. In the

last phase, the performance of the ANN was evaluated by comparing the predicted values of the ANN and the actual values in the testing set. One measure was the ability of the ANN to correctly classify the AWA types selected by high-tech companies. The other measure was the ability of the ANN to correctly classify satisfaction level reported by the high-tech companies.

1.7.10 Model Testing and Validation

For the first validation of decision model using prediction accuracy and the average percentage error (PE), the prediction of the ANN model and the actual results were compared. In the testing set, the overall prediction accuracy was slightly lower: the ANN was able to correctly classify 10 out of 12 AWA type selections, yielding 83.3% accuracy and it was also able to correctly classify 11 out of 12 satisfaction levels, yielding 91.67% accuracy. The average percentage error was 7.64% for type selection and 2.78% for satisfaction level.

For the second model validation step, this research also adopted case-based reasoning (CBR) to compare the prediction accuracy of the ANN with the one of CBR. CBR is a problem solving technique in which past cases and experiences are re-used to find a solution to particular problems. It is a method of capturing a new experience and making it immediately available for problem solving. CBR can be considered a learning and knowledge-discovery approach because it can capture some general knowledge from new experience (Shin and Han, 2001). By calculating the percentage similarity based on the nearest neighbor approach, CBR can indicate the similarity between stored cases and newly input cases. The training set consisting of 52 cases was stored in the case base, and these data were used to calculate the percentage similarity and to retrieve a similar case based on the percentage similarity.

The CBR model was able to correctly classify 10 out of 12 AWA type selections, yielding 83.3% accuracy. This prediction accuracy of the CBR model on type selections (Y1) was the same as the ANN model's prediction accuracy. Next, the CBR model was also able to correctly classify 5 out of 12 satisfaction levels, yielding 58.33% accuracy, which is much lower than the accuracy of the ANN model.

Finally, the prediction accuracy and the percentage error (PE) of the ANN model and CBR model were compared. The average percentage errors of the ANN model for predicting Y1 and Y2 are 7.64% and 2.78% respectively, whereas the average percentage errors of CBR model for predicting Y1 and Y2 are 8.89% and 15.28% respectively. Additionally, prediction accuracy of the ANN models for Y2 indicates 91.67%, whereas the accuracy of the CBR model for Y2 shows 58.33%. Therefore, it is validated that the ANN model is more effective and robust in predictive performance than the CBR model.

1.8 Summary, conclusions and future research

This dissertation has resulted in the development of readiness level assessment indicators (RLAI) which measure the initial readiness of high-tech companies for adopting AWA and the ANN based decision model, which allows facility managers to predict an appropriate AWA type and the satisfaction level considering an organization's objectives and current readiness level. This research has identified significant factors and relative attributes for facility managers to consider in measuring their organization's readiness for AWA adoption.

Based on the analysis of data and the ANN decision support model, the following have been concluded. Conclusions are explained more in detail in Chapter 6.

- Among 18 variables used to measure the readiness level of each case, 16 of the variables are positively correlated with the satisfaction level of AWA adoption. Therefore, it is concluded that the hypothesis of this dissertation is confirmed:

H: A positive rank correlation exists between organizational readiness level for AWA adoption and organization's satisfaction with AWA.

- Three important features are revealed from analyzing only 33 relatively successful adoption cases.
  - More important objectives for different AWA types are identified.
  - The average overcoming levels of off-site types are higher than the ones of on-site types in the three measurement areas.
  - The average appropriateness levels of off-site types indicate higher than the ones of on-site types in 11 areas.

- Among the objective variables, relatively more important variables in predicting an appropriate AWA type and anticipated satisfaction level are identified.

- Among the objective variables and the readiness variables used as the inputs for the ANN modeling, the more sensitive variables are identified. The term "sensitive input variables" means that the output variables change greatly when the input variables change.

- Finally, the ANN-based decision support model is developed and validated. Robust predictive performance of the ANN model shows that the main factors or key determinants have been correctly identified in RLAI and can be used to predict an appropriate AWA type and satisfaction level of AWA adoption for high-tech companies.

The scope of this research is limited to only the initiation stage and the adoption stage. In the future, the scope of research will need to be extended to the next stage, implementation, where a detailed feasibility study including cost estimation and risk analysis for the final adoption decision should be conducted. With 64 adoption cases, the ANN-based decision model provides more accurate prediction of actual values than the CBR-based one does. In future research, based upon a larger sample of AWA adoption cases from other industries, more efforts need to be made to develop a decision support system which can provide mode accurate and solid predictions on AWA adoption decision issues as well as measuring the performance of distributed workers.

CHAPTER 2

LITERATURE REVIEW

2.1 Purpose

The purpose of this chapter is to provide a review of the literature on wide rage of AWA issues and to summarize major business reasons, significant factors and relevant attributes of AWA adoption. The review of the literature starts with some background of AWA, a definition of AWA, various types of AWA, and some common problems. Next, this chapter reviews innovation attributes and selects significant innovation attributes that have been found more important in influencing adoption decisions.

The Innovation theory (Roger, 1995) can serve as a foundation for facility managers to start considering the adoption of AWA as an organizational innovation specifically for the workplace. Among the attributes speeding the adoption of organizational innovation, which is AWA in this research, the ones found to be most important in influencing adoption decisions are relative advantage, compatibility and complexity. From these three innovation attributes, three factors of AWA category are extracted: business reasons, appropriateness, and challenges.

Factors and attributes of AWA category are reviewed and explained to build up foundations of readiness level assessment indicators (RLAI). Detailed assessment items will be described later in Chapter 3. How the factors and attributes which are developed from the innovation attributes are shown in Figure 2.3. Significant factors and attributes, which have been identified based on the frequency of their citations, are tabulated in Table 2.5 at this end of this chapter. The literature review table with a full list is in Appendix B.

2.2 Background

A growing body of evidence shows that globalization and advances in information and communication technology (ICT) have prompted a revolution in the way work is produced. One of the most notable changes is the establishment of the alternative workplace arrangement (AWA), in which workers have more freedom in their work hours and workplaces. As more and more businesses have begun to adopt AWA, the number of employees who are working away from a permanently assigned office space and who are geographically and virtually distributed has been increasing throughout the world (Venezia et al., 2007).

According to Telework Trendlines 2009, more Americans than ever before were involved in AWA in 2008. This report indicates an increase in the number of Americans who work at home or at workplaces other than the central office, including satellite and virtual offices, at least one day per month from 28.7 million in 2006 to 33.7 million in 2008 (Johnson, 2009). Nemertes' benchmark study of 2007 discloses that 83% of the participating organizations considered their workplace structure as virtual where 91% of the participating organizations' employees worked outside of headquarters and about 96% of them utilized some forms of real-time collaboration tools such as Web conferencing, instant messaging and video conferencing.

As companies seek to retain talented, knowledgeable workers in order to remain competitive in a world with increasing real estate costs, air pollution, and traffic congestion resulting from mass commuting, (Roper and Kim, 2007), adopters of AWA have reported clear benefits such as reduced operating costs by space savings (Higa and Shin 2003; Cascio, 2000) improved productivity, retention of skilled knowledge workers (Gordon, 1988; Kurland and Bailey, 1999), reduced turnover and absenteeism (Kurland and Bailey, 1999), improved customer satisfaction (Peters et al., 2004), reduced traffic congestion and environmental impacts(Belanger and Collins, 1998), improved

employees' work-life balance(Belanger and Collins, 1998; Cascio, 2000), higher profits, and access to global market (Cascio, 2000).

Thus, the trend of AWA is likely to continue in the future, leading to greater reductions in the traditional ratio of workers to workspace, particularly in large companies. To successfully respond to the various demands of the competitive business environment (Martinez-Sanchez et. al., 2008) and to adapt to the growth of AWA, more and more organizations are moving away from their physical headquarters and entering larger networks across cities and countries. All of these changes have forced them to reevaluate their goals and find solutions to the challenges they face by adopting AWA, ICTs, and other workplace practices (Harrisoin and Steggles, 2005; Roper and Kim, 2007).

With the growth of alternative workplace options, such as hoteling, sharing space on-site, telecommuting, satellite officing, home officing and virtual officing, productivity is expected to increase. While Hequet (1994) states that pilot studies of home officing revealed that the average productivity increased by 10-16%, Qvortrup (1998) says that the results of teleworking have often been poor. Some AWAs today neither add much value nor work effectively because of poor managerial controls for the AWA environment. There is considerable uncertainty about others' behaviors in distributed work arrangements. To reduce this kind of uncertainty, companies need to find a way to give group members information about their remote work and what other group members are doing (Hinds and Kiesler, 2002). Managers need to hold regular meetings and review sessions with specific goals to manage distributed workers. At the same time, these managers must be available to coach these remote workers (Pancucci, 1995)

The rapid rate of business pattern change impacts the workplace. As organizational practices evolve, the workplace is typically unable to adapt as quickly as needed. Thus, what is now needed is a way to provide assistance for decision makers as they assess their readiness for AWA by providing them with information regarding which

types of AWAs are most appropriate given the organization's objectives of adoption, current conditions and challenges.

2.3 Defining Alternative Workplace Arrangements (AWA)

Many researchers use the term alternative workplace arrangements (AWA) loosely and interchangeably with other terms. However, alternative workplace arrangements(AWA), flexible workplace arrangements (FWA), distributed workplace arrangements (DWA), remote workplace arrangements(RWA), telecommuting arrangements and teleworking arrangements are all similar terms implying workplace arrangements, (usually/often/almost always) aided by ICT, where employees do not have permanently assigned workspaces on company premises. This research unites all of these similar terms under the one term of alternative workplace arrangements (AWA). Also, in this research, .any employees working under an AWA setting are referred to as distributed workers

One thing that can help provide a clearer understanding and assessing an organization's readiness for AWA adoption is a definition of what is meant here by "distributed." Executive Producer of the Work Design collaborative, Jim Ware (2003), explains that we can consider a workforce "distributed" if it meets any one of the three following conditions:

1. Individual workers are in different physical locations.
2. Most normal communications and interactions, even with colleagues in the next office, are asynchronous.
3. Individual workers are not all employed by the same organization or are working within distinctively different parts of the same parent organization.

Various authors have defined the on- and off-site alternative workplace arrangements. AWA refers to a variety of workplace settings in which employees (Belanger and Collins, 1998):

1. Do not have a permanent workspace on company premises, or
2. Work at sties intentionally located to be nearer the employees' homes, or
3. Work at home

The first type of AWA can be represented by sharing an office or hoteling on-site, and the second type of AWA is a satellite office. The final type is a home office.

An AWA is a workplace arrangement aided by ICT, and workers can choose to work at a satellite office, a home office, a virtual office or any alternative location outside the traditional central office (Ndubisi and Kahraman, 2005); such as a workplace arrangement enabled by ICT that allow employees to work from remote locations (Sullivan, 2003), a workplace arrangement where employees do not have a permanent workspace on company premises in order to be more flexible (Belanger and Collins, 1998), or any workplace arrangement designed to facilitate execution of distributed work by the entire organization and examples include working at home office, satellite office, hoteling and mobile work. (Swan et al, 2004). AWAs are typically described as various workplace settings in which workers do not have a permanent workspace on an organization's premises and which may consist of many types of alternative workplace settings rather than traditional workplaces at an assigned workstation in the organization's main office. Therefore, the definition of AWA for this research is the workplace arrangements enabled by ICT that allow employees to work on or off-site.

2.4 Various Types of Alternative Workplaces

Flexibility is a key to the success of organizations due to its enormous impact on working conditions, productivity and performance (Origo and Pagani, 2008). The emergence of AWAs has altered the workplace and work time by altering how work is performed on a regular basis. Responding to the needs of a rapidly changing business environment, companies have created and adopted many different forms of alternative workplaces: on-site workplaces, such as free addresses; hoteling and group addresses;and off-site workplaces, such as telecommuting, satellite offices and so on (Gilleard and Rees, 1998).

According to Gibson (2003), there are three dimensions to an alternative workplace:

- Where it is located
- How the internal space is configured
- How the space is assigned and managed

Van Meel (2000) presented a framework that distinguishes alternative workplace solutions at three different levels: place, space and use, as shown in Table 2.1. This framework raises the following questions:

- How many different locations do distributed knowledge workers use for work? (Place)
- What are the layout features of the places? (Space-for example, enclosed/open layout)

- Which concepts of use are practiced to allocate space? (Use-for example, personalized or shared workplaces)

Table 2.1 Alternative Workplace Solutions at Three Levels

Level	Type	Description
Place	Central office	A building where the workplaces of employees from the same unit are located
	Satellite office	A telework office facilitated by the employer
	Home office	A workplace located in the residence of an employee
Space	Cellular office	An enclosed space designed to accommodate 1-3 workplaces
	Group office	An enclosed space designed to accommodate 4-12 workplaces
	Open-plan-office	An enclosed space designed to accommodate 12 or more workplaces
Use	Personal office	A workplace used exclusively by a single employee
	Shared office	A workplace assigned to two or more employees
	Hoteling	Workplaces which must be reserved by employees in advance

(Van Meel, 2000)

There are more forms of AWAs, including the concept of supplemental workplaces where job-related tasks are also performed by full-time workers at home after regular work hours or on weekends (Venkatesh and Vitalari, 1992). Another form of AWA is the remote workplace, defined as those where workers are physically separated from managers (Staples, 2001).

In exploring various types of AWA, this research is limited to only primary places for work. If employees work in an alternative workplace only part of the time and still retain the permanently assigned workspace at the central office, organizations cannot expect to reduce their business cost because they have not actually implemented an AWA. Higa and Shin (2003) analyze participating organizations and find more successful AWA adoptions in cases where full-time AWA is implemented. Therefore, only primary place for work and full-time AWAs are considered in this study. Other types of AWA, such as mixed (e.g. hoteling and home office), part-time, and supplemental work-at-home AWAs are not examined in this research.

In a literature review focusing on a primary place of work, AWAs are limited to six recurring types: on-site workplaces, such as hoteling; group addresses; shared offices; off-site workplaces, such as satellite offices; home offices, and virtual offices. These are shown in Table 2.2. Off-site types are selected based on the place of work. On-site types can be differently classified by their space configuration (e.g. group office) and usage (e.g. hoteling and shared office), and all three of the selected on-site types for this research can be combined into a single type according to a usage perspective. It is critical to mention that the on-site types being considered in this research were selected because of their popularity in practice. One of the main purposes of this research is to suggest the most appropriate AWA type given an organization's initial readiness, not simply to classify AWA types; therefore, when selecting on-site AWA types for this research, it is assumed that it is reasonable to consider their popularity in practice and their recurrence in the literature.

Table 1.2 AWA Types Selected

Place	AWA Type
On-site AWA	Hoteling
	Shared office
	Group address
Off-site AWA	Satellite office
	Home office
	Virtual office

Definitions of these six workplace types are as follows:

1. **Hoteling** is an on-site AWA where workspace is reserved on a first call basis (Gilleard and Rees, 1998). It is similar to both free address, which is unassigned workstations available on a first-come, first served basis and hot desking, which is reservation-less unassigned seating (US GSA, 2009).

2. A **shared office** is an on-site AWA where workplaces are assigned to two or more employees (Van Meel, 2000). This is similar to desk sharing, in which two or more employees share the same workstation in a typically pre-arranged manner that allows each of the employees to have sole access to the specified workstation on given days while the others involved in the sharing arrangement work elsewhere (US GSA, 2009).

3. A **group address** is an on-site AWA that is designated for group or team work space for a specified period of time (Gilleard and Rees, 1998). A group address is sometimes called a project team environment where flexible work areas are designed to support work teams. This type is an enclosed space designed to accommodate 4-12 workplaces (Van Meel, 2000).

4. A **satellite office** is an off-site AWA where office is located in close proximity to a customer or supplier. Satellite office provides ICT and administrative support like corporate office (Fritz et. al, 1994).

5. A **home office** is an off-site AWA where all the work is performed at home. It is interchangeably referred to as WAH (work at home), WFH (work from home), teleworking or telecommuting (Stevens and Szajna, 1998).

6. A **virtual office** is an off-site AWA where, by using ICT capabilities, workers conduct work anywhere, such as hotel rooms, airports, airplanes, or automobiles. Employees have freedom to office anywhere through the use of portable technology. The actual physical locations of the employees working in a virtual office can be temporary or permanent and can be nearly anywhere. In this research, a virtual office is categorized as an off-site type (US GSA, 2009).

2.5 Problems

Lyne (1995) notes that today's organizations need a comprehensive view of the whole organization in order to facilitate effective workplace decision-making. Organizations should be able to successfully respond to the various demands of the competitive business environment by adapting to the growth of AWAs. As described already, many different forms of alternative workplaces have been created and adopted to respond to the needs of a rapidly changing business environment. It is challenging for researchers to appropriately assess the readiness of organizations in order to determine whether AWA adoption is a feasible alternative to meet their changing needs.

Unfortunately, there is currently little guidance available about which organization, work types, workers or workspaces are compatible for AWA programs (Belanger and Collins, 1998) and limited research about how the decision to adopt a particular type of workplace arrangements should be made (Fritz et al., 1996). Today's

enterprises need assistance in assessing their readiness for AWAs and developing an alternative workplace strategy (Harrison 2002). There have been research efforts to define relationships among factors of AWAs, but these efforts have not proved useful for the real world (Belanger & Collins, 1998), and there has been a lack of theoretical support for most of the AWA factors in this field of research (Shin, et. al., 2000).

The main problem is that decision makers have limited tools to assess their readiness for AWA adoption and to select the most appropriate type of AWA from the possible choices considering their organizations' objectives and their current readiness levels. Therefore, expanding on prior research, this dissertation attempts to build a foundation for initial readiness assessment for AWA adoption by identifying a theoretical foundation from which significant parameters can be persuasively derived and suggesting major categories in AWA along with specific factors and attributes.

2.6 Innovation Diffusion Theory

Many researchers describe an innovation as a new idea, policy, process, product or program. Tornatzky and Fleischer (1990) viewed an organizational innovation as the introduction of a practice, device, or concept that is perceived as new by the adopting organization. An organization tends to take innovation behaviors either when it recognizes the need for change or when a new technology that can increase its performance becomes available (Utterback, 1971). Adopting an AWA as an alternative form of workplace arrangement would, therefore, constitute an innovation in an organization (Ruppel and Harrington, 1995). Lin (1998) found that whether innovation is perceived as useful, advantageous and complex or not affects the decision to adopt because, for instance, innovations compatible with existing conditions imply that the risk of failure in adopting the organizational innovation is reduced. Larger organizations tend to adopt more innovations due to their greater number of ideas, their greater need for

innovation in competitive environments and their greater access to resources (Tornatzky and Fleischer, 1990).

In innovation diffusion theory, there are five perceived innovation attributes influencing adoption intention: relative advantage, compatibility, complexity, observability, and trialability (Rogers 1995). The five different attributes reflect a desire for maximum generality and succinctness. These attributes are empirically interrelated; however, they are conceptually distinct. Ruppel and Harrington (1995) applied innovation theory to identify factors affecting organizations adopting AWA by focusing on the relationship between compatibility and the AWA adoption, diffusion and success among IS personnel. It was found that the organization's practical compatibility is a major facilitator of the adoption and diffusion of an AWA.

The innovation theory can serve as a foundation for decision makers to start considering the adoption of an AWA as an organizational innovation, specifically a workplace innovation. Among the characteristics of an AWA, the most important for influencing an adoption decision and speeding the adoption of organizational innovation, which is AWA in this research, are relative advantage, compatibility and complexity (Karnowski and White, 2002, Sia et. al., 2004). These are shown in Figure 2.1. It is assumed that innovation attributes influencing adoption decisions can be used as a guideline for developing parameters for readiness assessment because when innovation attributes influence the adoption decisions, it means, these attributes provide assessment areas which can be examined closely to see whether the adopting organizations are ready to adopt or not. Therefore, relative advantage, compatibility and complexity are selected to guide any investigation of business reasons, significant factors and attributes useful for the readiness assessment of AWA adoption.

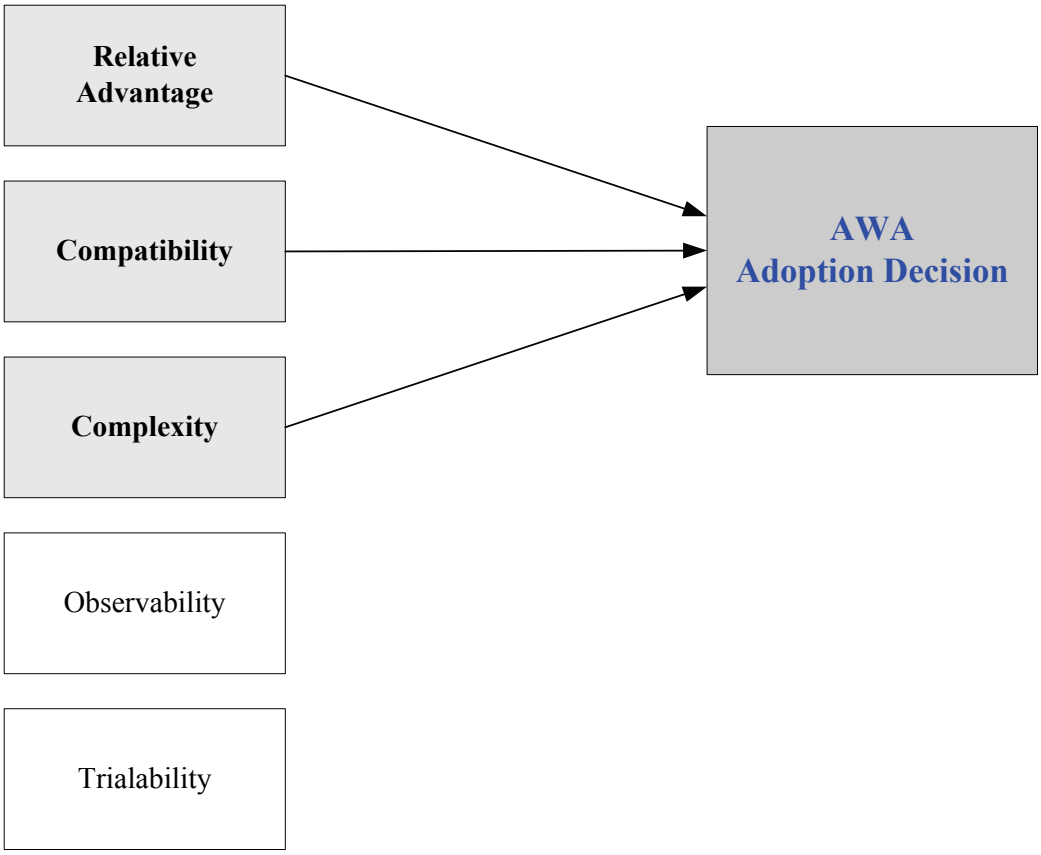


Figure 2.1 Innovation Attributes Affecting AWA Adoption Decision

Observability and trialability attributes are not included in this research for two reasons. First, relative advantage, compatibility and complexity are found more important in influencing an adoption decision. Second, observability and trialability of AWAs are viewed as less relevant for the adoption stage, but more relevant for the implementation stage, which is beyond the scope of this research. The three innovation attributes selected for this research are explained in the following sections.

2.6.1 Relative Advantage

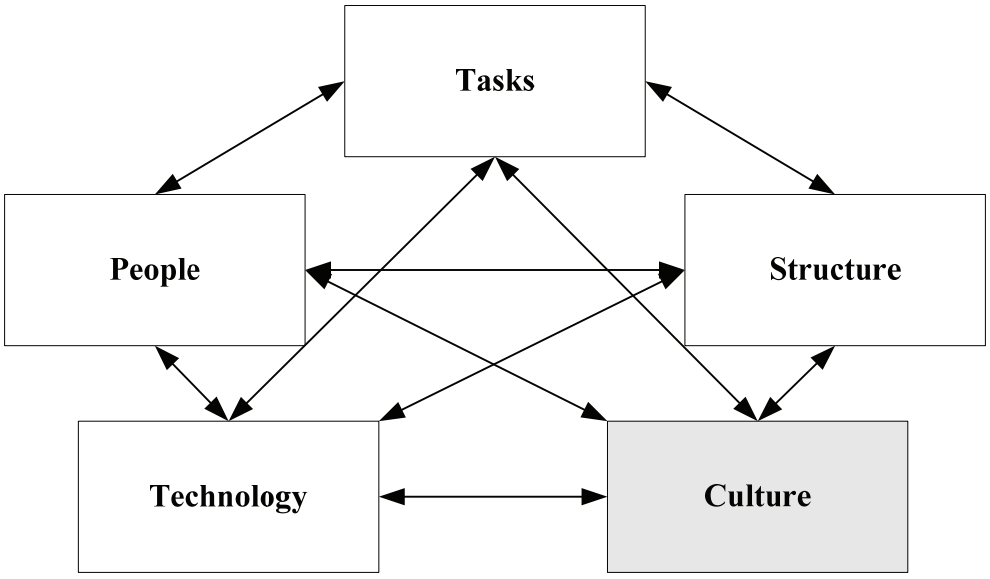
Relative advantage can be described as the degree to which an organizational innovation is considered as being beneficial over the existing one (Roger, 1995). The business reasons for adopting an AWA can be derived from relative the advantage

attribute in innovation theory. The business reasons for AWA adoption, for instance, could focus on office space cost savings and improved productivity, and these reasons should match the expected benefits of establishing a particular AWA (Roper and Kim, 2007). Obvious and potential organizational benefits exist, but tangible as well as less tangible benefits of AWA adoption also exist. Various benefits are introduced in a later section.

2.6.2 Compatibility

Compatibility is the degree to which an organizational innovation is considered consistent with existing conditions (Rogers 1995). These can include organizational culture, values, employee preferences and ability to conduct work, work type, work process, and facilities support, etc. The degree to which an AWA is seen as compatible will affect the positive attitude of the decision maker toward the AWA (Clark, 1998). Greater compatibility between the organization and an innovation is preferable because it presents the potential adopter with less uncertainty and allows the interpretation of the innovation in a more familiar context (Rogers 1995). Thus, when organizations perceive that innovation is compatible with their conditions, they make a positive decision regarding adoption. Fritz et. al. (1998) found a positive association between compatibility and adoption. In contrast, organizations with poor ICT infrastructure, highly bureaucratic structures, and incompetent managers are generally less likely to adopt any AWA (Olson 1988).

Leavitt states that an organization consists of four interrelated components (Leavitt, 1965), and many scholars add organizational culture as a fifth component. Gordon and Olson (1985) modified Leavitt's model to include this culture. Factors and attributes included in measuring compatibility will be selected from the five organizational subsystems as depicted in Figure 2.2



Gordon and Olson (1985)

Figure 2.2 An Alternative Model of Organizational Subsystems

2.6.3 Complexity

Finally, complexity is the degree to which an organizational innovation is considered difficult to implement (Rogers 1995). AWA is a complex organizational innovation and complexity reduces the chance of adoption (Cooper and Zmud, 1990). Complex innovation requires greater skills and efforts to adopt so complexity has been recognized as a challenge for adoption. (Rogers 1995).

2.7 AWA Category

As mentioned previously, innovation attributes influencing adoption decisions can be used as a guideline for developing parameters for readiness assessment. Therefore, relative advantage, compatibility and complexity will be used to investigate factors in

each of the three AWA categories: business reasons, appropriateness and challenges. From a readiness assessment standpoint, business reasons are represented as objectives and how clearly objectives of AWA adoption are identified and selected will be assessed. Next, appropriateness is measured as appropriateness level and how appropriate in general the AWA adoption is with existing conditions will be evaluated. Finally, challenges are measured as overcoming level. It measures whether or not managerial control practices exist, and if they do exist, evaluates how actively they are practiced.

All the factors and attributes are extracted from each AWA category and readiness assessment areas to build up readiness level assessment indicators (RLAI) as shown in Figure 2.2. The three factors of, business reasons, appropriateness, and challenges will be explained along with significant factors and relevant attributes in this chapter. Chapter 3 will then describe detailed assessment indicators.

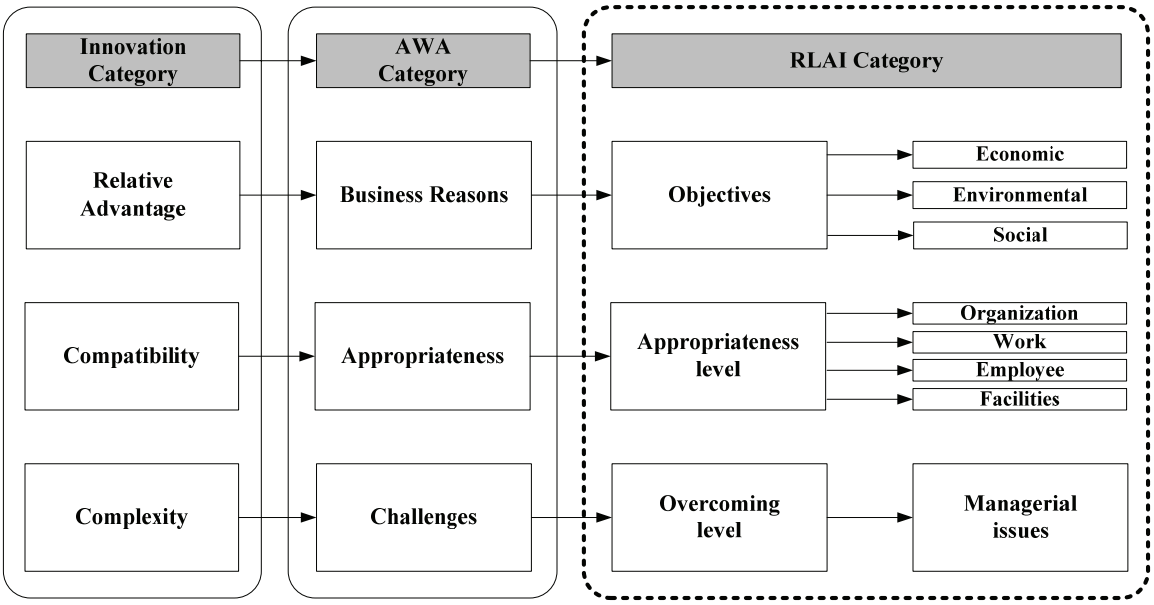


Figure 2.3 Development Process for the Assessment Indicators

2.7.1 Business Reasons

Adopters of AWAs have reported clear benefits such as reduced operating costs by office space savings and requirement parking spaces, improved productivity, ease in staff recruitment and retention of skilled knowledge workers, reduced turnover and absenteeism, improved customer satisfaction, reduced traffic congestion and environmental impacts, improved employees' work-life balance, provision of working opportunities for the elderly & handicapped (Belanger and Collins, 1998; Kurland and Bailey, 1999; Cascio, 2000; Higa and Shin 2003; Peters et al., 2004).

David Elkington (1998) coined the concept of the Triple Bottom Line (TBL), which he introduced to emphasize that a single dimension of economic value alone cannot fully explain various benefits. Thus, reporting on social and environmental performance is also necessary to explore its various benefits. The TBL concept provides with convincing approach to appreciate business reasons of AWA adoption from three aspects. Various business reasons for AWA adoption can fall into three categories as classified in the triple bottom line (TBL) as depicted in Table 2.3.

Table 2.3 Reasons for AWA Adoption in the TBL Concept

Triple bottom line(TBL) category	Adoption reasons
Economic	Retention/attraction of skilled workers
	Reduced office space costs
	Improved productivity
	Reduced turnover and absenteeism
	Improved customer satisfaction
Environmental	Reduced traffic congestion, better air quality
Social	Employment opportunities for aging and handicapped people, better employee work-life balance

As mentioned above, many business reasons for AWA can fall into three categories in the triple bottom line (TBL). AWA is an organizational phenomenon and its success is usually decided organizationally rather than by individual factors (Shin et al., 2000). Researchers have paid less attention to organizational focus whereas they have put a great deal of effort into studying social issues, worker related factors and IT issues (Shin et al., 2000; Ndubisi and Kahraman, 2005). Only a few studies have concluded that organizations adopt AWA to benefit employees (Illegems, 2001). The level of relative advantage of AWA adoption is usually expressed in economic benefits (Roger, 1995). Therefore more economic reasons for AWA other than environmental and social reasons are listed at the organizational level in this research.

The author discussed the organizational objectives for AWA adoption with the Tokyo Institute of Technology's professor Higa, who served as a panel member for this research. According to his research,, there are two types of adoption models: the corporate social responsibility (CSR) model and the business process reengineering

(BPR) model. Professor Higa has found that there are companies that adopt AWA to satisfy their CSR objectives, such as employee work-life balance, whereas other companies adopt AWA to improve the organizational performance by reducing costs and improving productivity. Additionally, he has found that there are more part-time distributed workers in CSR models, whereas there are more full-time distributed workers in BPR models. When there are more full-time distributed workers in the organization, upper management's strong commitment to AWA and ICT support are highly emphasized. The target organizations for this research are high-tech companies. Since it was not possible to assume which adoption model the participating companies wanted to adopt, it was decided to let the participating companies select their objectives for AWA adoption from the seven objectives selected for this research.

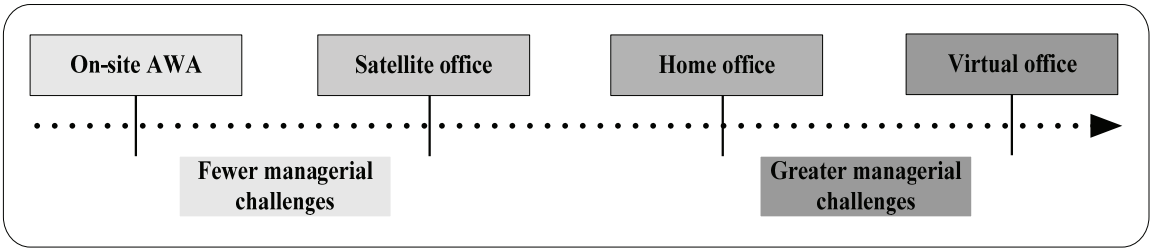
2.7.2 Challenges

At the organizational level, control, coordination and supervision of distributed workers are much harder than they are for workers on-site. Most challenges in adopting AWA are found in the area of managerial issues, including performance evaluation and coordination from the organizational perspective. It is assumed that well-prepared managerial actions including a wide range of activities dealing with challenges in AWA settings can positively influence the success of AWA adoption. Areas in which AWA can lead to difficulties are performance evaluation, supervision, coordination, policy and guideline provision and learning opportunities for distributed workers (Fritz et. al., 1996; Fritz et. al., 1998; Apgar, 1998; Kurland and Bailey, 1999; Cascio, 2000; Felstead et al., 2003; Watad and Will, 2003; Roitz and Jackson, 2006).

The irregular presence of distributed workers is the main challenge for managing on-site AWAs and the physical separation and interaction of distributed workers is the main challenge for managing off-site AWAs (Cascio, 2000). Although managing on-site

distributed workers is relatively easier than managing off-site workers, but the irregular presence of on-site workers at the workplace makes it difficult to manage them. Managerial control in an AWA setting is characterized by the inability of managers to observe their employees' work processes (Kurland and Bailey, 1999).

When a significant amount of work time is performed by off-site distributed workers, managers face an even greater challenge to physically observe the workers' performance. Assuming that managers are all located at the central office, there would be fewer challenges for an AWA that is on-site and it seems hard to distinguish challenge levels of the various types of on-site AWAs. Managerial challenges become greater as distributed workers are further from the central office in terms of physical distance as shown in Figure 2.4.



(Modified from the model of Kurland and Bailey, 1999)

Figure 2.4 A Continuum of the Managerial Challenges in AWA

Even if managers can easily focus more on outcomes rather than processes in evaluating sales workers performance, measuring and monitoring the performance of many other types of distributed workers remains problematic. Therefore, organizations need to supplement an outcome focus with frequent communication. Performance measurement of distributed workers is one of the biggest challenges in AWA environment (Cascio, 2000). Managers can begin to manage distributed workers by

assessing results rather than processes and by setting up clear goals at the outset. There should be an agreement between managers and distributed workers on a way to monitor progress and measure performance. This agreement is critical to the success of any AWA adoption (Apgar, 1998).

Coordination is the process of linking the activities of different distributed workers together to accomplish the objectives of an organization's AWA adoption (Fritz et. al., 1998). Coordination of AWA work activities gets more complex because goals and objectives should be communicated to all the distributed workers, who may be in a variety of physical locations. Managers sometimes want face to face (FTF) communication with workers by holding schedule or unscheduled meeting to effectively communicate goals and coordinate work activities. AWA adoption challenges organizations to establish clear policies and guidelines. (Kurland and Bailey, 1999).Written policies, guidelines and procedures often make AWA programs more understandable. Policies should cover short-term as well as continuing workplace arrangements, and guidelines should provide distributed workers and managers with covering topics such as scheduling, communication expectations, performance expectations, eligibilities, expense policies and how to maintain healthy relationships among distributed workers. Orientation sessions for distributed workers and their managers can ensure a common understanding of AWA program requirements.

There are significant opportunities for enhancing the readiness for AWA adoption through a wide variety of management actions. Consequently the organizations need to develop new techniques and tools for remotely controlling and coordinating distributed workers (Fritz et al., 1996). In an AWA environment, new methods of coordinating and measuring performance are needed for managers to effectively coordinate work activities in a timely manner. Making pertinent use of real-time collaboration tools for performance evaluation, supervision, virtual teamwork, learning opportunities for distributed workers, to some extent, is expected to successfully deal with managerial challenges in AWA

environments. Some organizations such as Merrill Lynch provide telecommuters training and equipment with the same software existing in the central office (Kurland and Bailey, 1999). Additionally, attempting to create the visibility of distributed workers by means of virtual software ensuring effective flow of information to and from flexibly distributed workers is found in numerous organizations, however, relatively few is there due to high cost (Felstead et al., 2003).

All the measurement items listed above are important; however, the key point is whether managers possess sufficient skills to evaluate, supervise and coordinate remotely. Regardless of the setting up of well-defined rules, policies and systems for managing distributed workers, if managers do not have sufficient skills to manage, it does not mean anything. Pancucci (1995) suggests that managers must be able to manage distributed workers, and they should be available to coach them and hold regular meetings and review sessions with them. Workplace decision-making should provide a productive work environment across the organizational network. Decision makers are responsible for evaluating their establishment capacity of managerial control and coordination over AWA to effectively assess their readiness to adopt AWA.

2.7.3 Appropriateness

When the adoption of an AWA is seen as suitable given an organization's existing conditions, it can be concluded that the organization is ready to adopt the AWA. The existing conditions can be represented as significant factors surrounding the AWA.

Leavitt selected four elements for describing an organization: technology, structure, task and people (Leavitt, 1965), and management scholars added organizational culture to the four elements selected by Leavitt (Gordon and Olson, 1985). These elements gave an outline at the beginning to identify the important factors for AWA adoption when measuring appropriateness for a given organization.

Much scholarly work has been done on the topic of AWA, especially on the significant factors and characteristics to be considered for AWA adoption. In their conceptual model for AWA study, Venkatesh and Vitalari (1992) have provided three factors: organization/work, ICT, and household including worker's characteristics. All three independent variables are related to a fourth factor: supplemental work at home, which is the dependent variable in their study. The characteristics surrounding AWA are organizational, individual, work, household and technology characteristics (Belanger and Collins, 1998), and the AWA environments are separated into four components: social environment, technical environment, resource environment, and organizational structure environment (Swan et al., 2004). For AWA adoption to be successful, it is important to have work processes which are easily transformable into the AWA. It is also important to have the necessary ICT available. Also important are an organizational culture oriented towards evaluating work results rather than process and the promotion of autonomy. (Clear and Dickson, 2005).

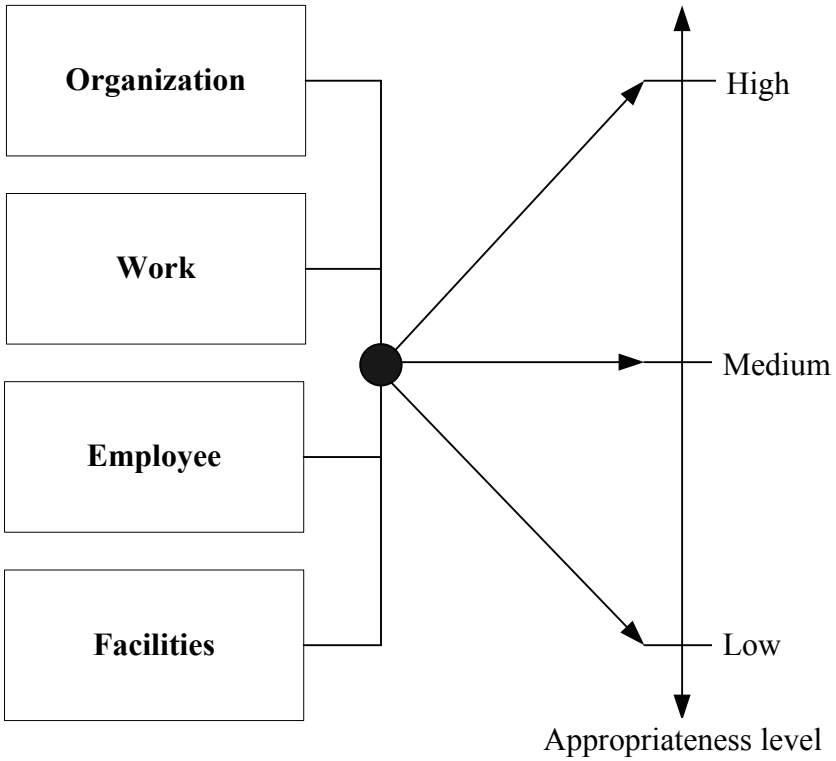
Numerous studies of AWA adoption have focused on organizational factors (Ruppel and Harrington, 1995), worker and task attributes (Kayworth and Leidner, 2002), and technological supports (Gupta and Somers, 1995). Kowalski and Swanson (2005) provide a framework of critical success factors including support, communication and trust that are instrumental for organizations looking to develop an AWA program. We can get a better understanding of the factors influencing AWA adoption by modeling four clearly distinguished explanatory clusters, notably organization, job, household and individual characteristics, using ICT equipment as an indicator for the adoption model (Peters et. al., 2004).

As work patterns and structures evolve faster than workplaces are able to adapt, business patterns are also dramatically changing. AWAs can be attractive to large organizations due to their potential benefits, but organizations need to consider whether or not their goals, objectives, and surrounding conditions, as well as characteristics of

their work, workers, and work environment, are appropriately suited for readiness assessment. To develop factors for AWA readiness assessment, Venkatesh and Vitalari (1992) viewed supplement behavior as a function of three factors in a conceptual model for supplemental work at home:

1. Organization/ Work
2. Information Technology
3. Household, including individual characteristics

There was much in common between Leavitt's organizational elements and the significant factors selected for many AWA research studies as shown above. The four factors selected for measuring appropriateness toward AWA adoption include the organization, work, employees and facilities as depicted in Figure 2.5.



(Roper and Kim, 2007)

Figure 2.5 Four Factors selected for Measuring Appropriateness

The self-evaluation table is provided to show an example of how to quickly assess the potential appropriateness for establishing an AWA, especially for a home office, as shown in Table 2.4. The table is useful for the company owner facing a quick decision regarding establishment of a home office setting. It is assumed in this example that the four parameters are all equally important for establishing a home office, so all levels of attributes are equally weighted to make self-evaluation easier in this demonstration.

Table 2.4 Self-Evaluation Table for Home Office

Factors	Attributes	Appropriateness	Weight	Your case
Organization	Objective	fitness to outcome of AWA	1/4	1,2, or 3
	Culture	friendliness to AWA		1,2, or 3
	Control	suitableness to AWA		1,2, or 3
Work	Nature	fitness to AWA	1/4	1,2, or 3
	Pattern	level of interaction needed		1,2, or 3
	Process	reciprocal vs sequential		1,2, or 3
Employee	Objective	fitness to AWA	1/4	1,2, or 3
	Preference	level of preference to AWA		1,2, or 3
	Adaptability	level of self-sufficiency		1,2, or 3
Facilities	ICT	level of support	1/4	1,2, or 3
	Office	level of support		1,2, or 3
	Business	level of support		1,2, or 3
TOTAL			1	32 in max.

There are 12 equally weighted levels measuring the appropriateness of establishing a home office. It is assumed that an organization's level of readiness for AWA goes up as each level of appropriateness goes up. Users can input numbers for their own company at their own discretion. The range is from 1, as the lowest, to 3, as the highest. An exception is work parameter: from 1, as the highest, to 3, as the lowest level of interaction/communication needed and from 1, as the closest to a reciprocal process to 3, as the closet to a sequential process.

The higher the total score (closest to 32), the higher the level of readiness to establish a home office would be expected. Due to the fact that the relationship among given appropriateness levels, types of AWAs, and success of an AWA is a complex matter, further investigation of this is needed.

Due to the severe difficulty in formulating precise functional relationships among multiple AWA factors and attributes (Venkatraman, 1989), this research attempts to list features to consider when measuring the appropriateness of each factor and relevant attribute for AWA adoption. Depending on the existing conditions within the

organization, it is assumed that specific combinations of relevant attributes can be examined and the level of appropriateness can be determined. It is suggested that there should be a causal relationship between the AWA attributes and the readiness of the organization for AWA adoption, creating a need for further research focusing on identifying their specific causal relationship. This would involve manipulating independent variables, such as AWA attributes, and observing how dependent variables react to independent variables. It will need to be assumed that all AWA attributes are independent of each other to focus on analyzing the relationship between AWA attributes and any dependent variables such as the AWA type selected and the success level expressed in satisfaction. An analysis of these relationships is described in greater detail in chapter 5.

A review of each factor along with relevant attributes as well as a measure of the level of appropriateness of each are outlined.

2.7.3.1. Organization

Most organizations decide to adopt AWAs for cost savings, as well as for increased productivity. Organizational objectives could focus solely on cost savings or increased productivity, or on both; however, the objectives should closely match the expected benefits of establishing distributed work arrangements. As Becker & Steele (1994) state, objectives should be focused on creating a fun, lively, distributed work environment that workers enjoy and that supports the new ways of working. The type of AWA has to match not only the objectives of the organization but also its culture. The organizational culture of a company is the meaning shared by its members which differentiates the organization from others (Robbins and Judge, 2007). It is expected that an AWA can add more flexibility to the work settings so as to increase productivity; however, if the workers are moved into an AWA setting in which they feel outside the

specific organizational culture to such an extent they are afraid of losing their commitment to the organization or if they are feeling a disadvantage regarding promotion opportunities compared to those of workers who have permanent workspace in the office, it is not recommended that this type of organization establish an AWA (Roper and Kim, 2007). Organizations must carefully monitor their actions to assure that organizational culture and objectives are synchronized and that any change in culture does not create disadvantages for specific workers.

For AWA to be successful, it is critical that there be friendly support from all levels within the organization, including the top management, middle managers and first line supervisors. Distributed workers supported by their managers showed improved productivity, better work-life balance and a better relationship with the company (Haines et al., 2002). Additionally, the trust between workers and managers is an essential prerequisite in adopting alternative workplace practices (Martinez-Sanchez et. al., 2008) With all conditions highly congruent with AWA adoption, if there is lack of trust, the adoption will be less successful (Cisco, 2000).

2.7.3.2. Work

Not all work types and their characteristics are efficient candidates for an AWA setting. Valid attributes that need to be examined for work factors are the type of work, the work processes, the autonomy of the workers, the level of concentration required to perform the work, clearly defined deliverables and the worker's required physical presence at the office to be able to access specific technology, equipment or live interpersonal response (Olson, 1988; Belanger and Collins, 1998; Perez et al., 2003).

The most-appropriate type of work for an AWA is often less interactive. Examples of less-interactive work are jobs such as programming, copywriting, and graphic design, which need only periodic interaction with co-workers. Other types of

work are highly interactive, such as work required for managers, supervisors, and team members who need frequent interaction and communication with others.

Work process is determined by the way work is accomplished. The work processes can be simply divided into two types: the sequential or transactional work process, which reflects a one-way work flow and does not need frequent information exchange among workers to accomplish the tasks; or a mutual, reciprocal or open-ended work process that has complex work flow and needs frequent and fast information exchange, frequent coordination and team-work. Although advances in ICT, to some extent, can cover difficulties in communication and information exchange among distributed workers, generally, organizations with a sequential work process are a better fit for an AWA.

However, the suggested level will vary depending on different AWA types. For instance, sales, service, or consulting work performed under on-site type such as hoteling requires a high degree of interaction and communication. Generally, the more congruent characteristics for off-site AWAs such as a home office may be described as needing less interaction and communication, sequentially processed, allowing more autonomy, requiring more concentration with clearly defined deliverables and fewer physical presences required. Jobs which fit these characteristics are those such as writer, financial analyst, researcher, computer programmer, translator, telesales operator, data entry operator, and journalist, all people whose works merely need periodic interaction with co-workers (Roper and Kim, 2007).

2.7.3.3. Employee

Just as not all organizations are good candidates for an AWA, not all workers are good candidates for an AWA. Six attributes to consider for employees are their preference for an AWA, their self-sufficiency, personal effectiveness, communication skills, familiarity with ICT, and work experiences with flexible work styles.

The worker's preference for a work setting and the worker's ability to work in distributed work styles should be considered and evaluated (Roper and Kim, 2007). An AWA could be an innovative option for employees who need more flexibility with less supervision because they clearly know what has to be done and how to do it. This type is represented by knowledge workers, who usually a high need number of choices available to them as to when, where, and how their work is undertaken; therefore this type of employees would be better for AWA. Contrarily workers, who are less self-sufficient, less experienced and those who have a hard time prioritizing tasks or realizing how long things will take might need a high degree of face to face interaction, communications and direct supervision to effectively perform their work. For this type of employee, AWA might not be an effective option (Roper and Kim, 2007).

2.7.3.4. Facilities

Essential for AWA success are facilities support in terms of ICT, property and business as well as support from all levels in general. ICT is becoming increasingly essential at work. The current level of ICT support availability is a critical measure for the level of appropriateness in establishing an AWA. Although data required by workers varies by type of work, work process and worker's position, an organization must determine how distributed workers gain access to important data from distributed workplaces. Distributed work is supported if a number of means of connectivity, such as Internet, satellite, cable, FTTH, cellular, radio, wireless, and others, are all available for distributed workers, but if an organization does not have the right tool or software protecting its significant data, the level of ICT support may be assessed as poor (Roper and Kim, 2007).

Employees working in an AWA that is properly supported by ICT, utilities, furniture, business equipment, cleaning, maintenance and mail services have been found to be more satisfied with their works and show lower turnover and absenteeism (Ilozor et

al., 2001; Haines et al., 2002). This indicates that organizations should provide employees with effective facilities support in order for an AWA to be successful (Fritz et al., 1998). This support can include services such as cleaning, maintenance, mail, reservation systems, office set-up, applicable utilities, furniture and business equipment. An organization needs to support not only the physical work environment, but must also take care of work environment impacts, such as noise levels, lighting, office equipment, rent and utility supplement. It must also provide technical support for both the primary office, as well as for the home office or virtual workplace, in order to result in higher productivity and worker satisfaction.

According to the International Facility Management Association (IFMA), facility management (FM) is "A profession that encompasses multiple disciplines to ensure functionality of the built environment by integrating people, place, processes and technology". It is the responsibility of FM to effectively carry out support systems (Roper and Kim, 2007). Facility managers have the potential to promote and enhance the AWA environment since facility managers are responsible not only for the central office physical facilities but also for home office arrangements. However, no research has addressed the specific roles of facility managers in organizational AWA adoption issues (Zelinsky, 1997). The roles of FM will be discussed in chapter 3.

2.8 Decision Support Models for AWA

Numerous studies have attempted to find solutions for AWA adoption issues. (Fritz et. al., 1994) proposed a method for determining the suitability of an AWA implementation framework. (Bui et. al., 1996) have described various types of AWAs and discussed the suitability of each AWA type from the organizational perspective. Shin et al., (1997) have depicted a conceptual model of intra-organizational adoption of telework at four stages: initiation, adoption, implementation and institutionalization. Higa

and Wijayanayake, (2000) have delineated the adoption patterns of different AWA types by different areas and the size of organizations in Japan. Higa and Shin, (2003) have examined and compared five successful AWA adoption cases and four not-so-successful adoption cases in terms of four AWA adoption phases: inception, testing, implementation and future planning.

However, none of the decision models has shown clear evidence regarding its applicability to the AWA adoption decision process (Clark, 1998). A literature review reveals that there is little guidance about which organization, work types, workers and workspaces are compatible for AWA programs (Belanger and Collins, 1998), and no research about how the decision should be made to adopt a particular type of alternative workplace arrangement (Fritz et al., 1996). Today's enterprises need assistance in assessing their readiness for AWA and developing a distributed workplace strategy (Harrison 2002). The problem is that decision makers have no established tools to assess their readiness for AWA or to select among the most appropriate AWA type considering their organizations' business reasons of adoption and the current readiness conditions. It is now critical to come up with solutions that can help decision makers assess their initial readiness for AWA adoption in the Knowledge Age.

2.9 Summary

This chapter has provided a review of the literature of a wide range of AWA issues and summarized major business reasons, significant factors and relevant attributes. Significant factors and attributes have been identified based on the frequency of their citations as shown in Table 2.5. A literature review table with a full list appears in Appendix B. All of the identified factors and attributes will be combined to develop readiness level assessment indicators (RLAI) which will then be finalized through validation by an expert panel formed for this research. Expert validation processes are explained in Chapter 3.

Table 2.5 Literature table

Literature review table: Issues discussed																																							
Number	Author(s)	Year	Method	Appropriateness																														Challenges						
				Organizational characteristic					Work								Employee								Supports(facilities) issues				Managerial issues												
				Support	Fairness	Trust	Independency	Structure/size	Type	Process	Autonomy	Concentration	Deliverables	Physical presence	Knowledge work in nature	Traveling needs	Preference	Sufficiency	Effectiveness	Communication	Familiarity	Experience with AWA	Adaptability	Relationship	ICT	Premises supports	Business support services	Process administration	Result based Performance evaluation	Supervision	Coordination	Policy/guideline	Learning opportunities	Identity maintenance						
1	Ford & McLaughlin	1995	Survey	1	1	1											1	1	1	1		1			1		1													
2	Gupta et al.	1995	Survey						1	1															1															
3	Korzeniowski	1995	Case study	1	1	1								1											1															
4	Ruppel & Harrington	1995	Survey	1			1		1																				1		1	1							
5	Bui et. al	1996		1	1	1			1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1						
6	Fritz et al.	1996	Survey & Interviews	1	1		1		1	1	1	1	1	1			1	1			1	1	1	1	1			1		1	1	1	1	1						
7	Higa et. al	1996	Case study	1	1	1		1									1			1	1	1			1				1	1	1	1		1					
8	Lewis	1996	Case study	1	1	1			1	1							1				1	1			1														
9	McGonegle	1996	Case study	1		1	1										1																						
10	Pontell et al.	1996	Case study	1													1								1														
11	Raghuram et al.	1996	Interviews	1	1	1			1	1	1	1	1				1	1	1		1	1																	
12	Rognes et al.	1996	Case study	1													1	1	1	1	1	1			1														
13	Watad & Disanzo	1996	Case study	1	1												1								1		1													
14	Shin et al	1997		1							1	1	1																										
15	Belanger & Collins	1998		1	1	1			1	1	1	1	1				1	1		1		1			1	1			1	1	1		1						
16	Fritz et al.	1998	Survey	1					1	1		1	1	1						1	1	1			1					1			1						
17	Higa & Wijayanayake	1998	Survey	1	1	1		1			1	1	1	1		1																							
18	Kurland & Bailey	1999	Case study & Interviews	1	1	1			1	1	1		1	1			1	1		1	1	1			1	1	1		1		1	1	1						
72	Roper & Kim	2008		1	1	1			1	1		1	1	1			1	1							1	1	1		1	1	1								
Total frequency of citations				65	37	43	14	17	54	42	32	25	27	24	11	8	44	37	25	28	22	24	11	10	61	31	32	9	35	35	52	26	27	15						
Low: 1-20, Med: 21-40, High: 41+				High	Med	High	Low	Low	High	High	Med	Med	Med	Med	Low	Low	High	Med	Med	Med	Med	Med	Low	Low	High	Med	Med	Low	Med	Med	High	Med	Med	Low						

CHAPTER 3

READINESS LEVEL ASSESSMENT INDICATORS (RLAI)

3.1 Purpose

The purpose of this chapter is to develop readiness level assessment indicators (RLAI) for AWA adoption. The findings from the extensive review of the literature and the evaluations from the expert panel are combined to finalize assessment indicators for developing RLAI. The two major criteria for the final selection of significant factors, relevant attributes and assessment indicators were based on the following:

1. Citation frequency as shown in Table 2.5.
2. Experts evaluations

A total of 31 attributes from five major factors were identified through the review of literature. Then, as depicted in Table 2.5, the frequency of the citations was calculated and classified into three levels:

- Low: the frequency of citations falls between 1 and 20
- Medium: the frequency of citations falls between 21 and 40
- High: the frequency of citations is over 40

Only attributes classified as either medium or high were selected, and appropriate assessment indicators pertaining to attributes were developed for the experts' review. The purpose of forming the expert panel was to evaluate assessment indicators for the final use. Expert knowledge was needed for this research in two different stages. The author needed expert knowledge to validate the initial findings from the literature review at the

conference in 2008. Then a panel of experts was officially formed to validate the assessment indicators.

3.2 RLAI Category

The readiness indicators were developed in three categories for this research, and these categories of RLAI are defined as innovation attributes stemming from the innovation diffusion theory (Rogers, 1995). Relative advantage is substituted for objectives, complexity is substituted for overcoming level on challenges expected in managerial issues and compatibility is substituted for appropriateness level respectively in RLAI as depicted in Figure 3.1.

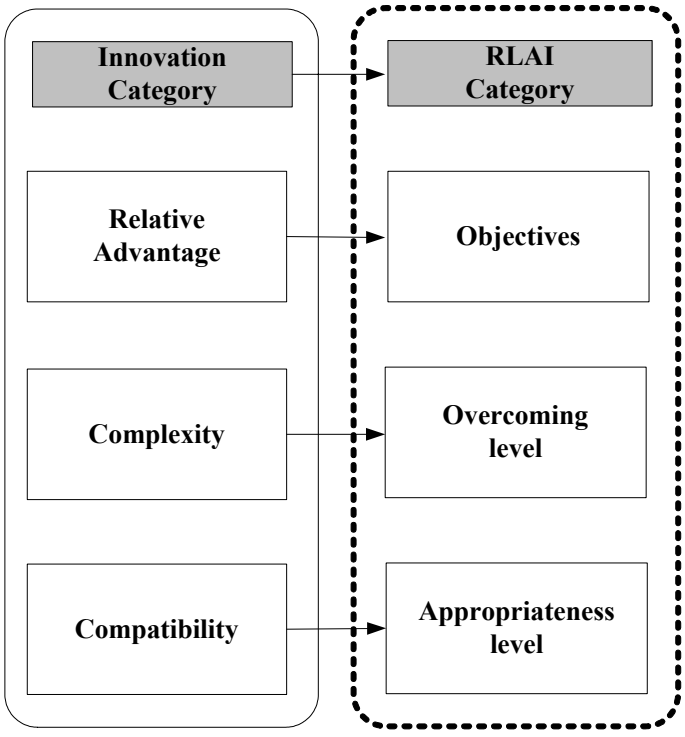


Figure 3.1 RLAI Category

The first category is objectives for AWA adoption identified through the review of literature and categorized in the triple bottom line (TBL). An organization should have clear business reasons for AWA adoption which support the goals and objectives of the organization. It has been found that the motivation in adopting AWA impacts the success of the adoption (Huws et. al., 1990; Belanger and Collins, 1998; Kurland and Bailey, 1999; Cascio, 2000; Higa and Shin 2003; Peters et al., 2004). Therefore, if objectives for adopting an AWA are not clearly identified within the organization, then the organization is not ready for the adoption of an AWA. The second category is overcoming level on challenges expected in managerial issues. Most challenges in adopting an AWA are found in the area of managerial issues, including performance evaluation and coordination from the organizational perspective (Cascio, 2000; Felstead et al., 2003; Watad and Will, 2003; Roitz and Jackson, 2006). The final category is appropriateness level in four different areas: organization, work, employee, and facilities (Leavitt, 1965; Gordon and Olson, 1985; Venkatesh and Vitalari, 1992; Ruppel and Harrington, 1995; Belanger and Collins, 1998; Kayworth and Leidner, 2002; Swan et al., 2004; Kowalski and Swanson, 2005).

In order to provide understanding in assessing the initial readiness for AWA adoption, readiness level assessment indicators (RLAIs) are developed to help decision makers find what to look for in assessing the extent of an organization's readiness for the adoption of an AWA. RLAIs can be used as important indicators which predict the potential successfulness of AWA adoption from an organizational perspective. RLAIs are a base for collecting real AWA adoption cases from high-tech companies to measure their initial readiness for AWA adoption as described in Chapter 4.

3.3 Expert Knowledge

The specific objective of this dissertation is to develop readiness level assessment indicators (RLAIs) for measuring the extent of an organization's readiness for the adoption of an AWA. RLAIs can be used as important indicators which suggest the types of appropriate AWA and predict the potential satisfaction of AWA adoption from an organizational perspective. In order to develop RLAIs, significant factors, relevant attributes and assessment indicators were identified through the extensive review of the literature in Chapter 2. Significant factors, attributes and assessment indicators should be validated by the industry experts. Expert help was needed in two different stages for this research.

First, the author attended the 2008 International Facility Management Association (IFMA) Atlanta Workplace and, as a speaker, addressed innovative workplace issues for all professionals. During the seminar, the author had a chance to discuss AWA issues identified from the review of the literature with eight innovative workplace professionals. These eight professionals are experts in the workplace industry and have prior experience in assessing readiness, making decisions of alternative workplace adoption, or working under some AWA settings. The predominant business reasons for AWA, the significant factors, and the relative attributes were discussed. The author was able to discuss issues in assessing AWA readiness and making decisions. The first survey was distributed to the eight professionals, and their answers were helpful for validating the initial findings and finalizing the scope of the literature review so as to build a foundation for the Readiness Level Assessment Indicators (RLAIs) to help organizations assess their own initial readiness for AWA adoption. The findings from the discussion and survey answers from these experts guided the author through the next steps.

Next, after conducting a comprehensive review of literature on a wide rage of AWA issues from an organizational perspective, obtaining feedback from the experts,

and attending seminars and conferences on innovative workplaces along with the review of the conference proceedings, the author gained further insights into important parameters of AWA adoption. More than 30 experts were identified, and finally 15 experts agreed to serve on the panel for this research. Finally, all major objectives of AWA adoption, the significant factors, the attributes and the relevant assessment indicators were evaluated by 15 experts to develop the RLAIs.

3.4 Design Survey and Approval Required

The survey questions, consisting of three main areas, were designed to effectively get feedback from the experts. Open-ended questions were not used because the qualitative information can be reduced while coding and because the answers are likely to lose their intended meaning. Thus, closed-ended questions with a three point ranking scale were used to effectively analyze the answers. Pre-testing was carried out after the initial draft survey questions were developed. The draft questions were provided to three experts to see whether items were clear to understand. Based on feedback from the pre-testing, the author changed the wording and the order of some items to finalize the survey questions.

Next, since human-based research requires special review and approval from the Institutional Review Board (IRB), the required training to obtain certification was completed, and the protocol of this research was submitted. The protocol, H09200, was approved by the Institutional Review Board (IRB).

3.5 Expert Panel Selection

Experts with practical experiences and theoretical knowledge of different aspects of AWA from both the industry and academia were finally selected for this research. The three main criteria used in identifying and selecting experts are as follows:

1. Either practical experience with or theoretical knowledge of AWA readiness assessment
2. Either practical experience or theoretical knowledge in AWA adoption decision making
3. Consent to serve and offer expert knowledge for this research

A total of 15 experts, including two experts already identified at 2008 IFMA Atlanta Workplace finally agreed to serve on the panel as shown in Table 3.1.

Table 3.1 Expert Panel List

Number	Name	Affiliation
E1	Aditi Sant	Bank of America
E2	Bob Skinner	USGSA
E3	Camille Venezia	Venezia Enterprises
E4	Chris Hood	Hewlett Packard
E5	France Belanger, Ph.D.	Virginia Tech
E6	Gil Gordon	Gil Gordon Associates
E7	Kunihiko Higa, Ph.D.	Tokyo Institute of Technology
E8	Kathy Kacher	Career/life alliance services
E9	Margaret Serrato, Ph.D.	Hermen Miller
E10	Mary Beth Watson-Manheim, Ph.D.	University of Illinois at Chicago
E11	Megan Tuggle	Ernest & Young
E12	Nancy Kurland, Ph.D.	Cal state University
E13	Paul Rupert	Rupert and company
E14	Stephanie Smith	AT&T
E15	Zheng Zhao, Ph.D.	University of Science and Technology of China

3.6 Content Validity

Content validity involves a systematic examination of the content to determine whether it covers a representative sample of the domain to be measured. Content validity is often used in academia, where test items should reflect the knowledge actually required for a given topic area (Anastasi and Urbina, 1997). The content validity can be improved if a panel of experts reviews the content and selects essential items (Foxcraft et. al., 2004). C.H. Lawshe (1975) developed the most widely used method of measuring content validity for gauging agreement among evaluation panel members regarding how essential each item is. Lawshe's approach is applied to justify the content validity of assessment items with the help of the expert panel.

First, expert panel members were asked to mark their three choices of general objectives of AWA adoption with an X in order to determine what the predominant objectives of adopting AWA are from the experts' perspective. These results were then compared with the major objectives selected for the actual adoption cases in Chapter 4. Next, according to a three-point scale ("1"= not necessary, "2"=important but not essential, "3"=essential), the experts were asked to rate the validity of each of the items stemming from the compatibility and complexity categories. Ensuring the adequacy of the assessment items, the content validity ratio (CVR), which is a very helpful item statistic in the retention or rejection of specific items (Lewis et al., 1995) was applied to ensure the adequacy of assessment items for the initial readiness assessment for AWA adoption. The expert panel consisted of a group of 15 professionals from both industry and academia, including five college professors knowledgeable about assessing the readiness of AWA adoption. In order to calculate the content validity ratio (CVR) for each assessment item, Equation 3.1 was utilized as follows:

$$CVR = (n - N/2)/(N/2) \tag{3.1}$$

in which n is the number of experts indicating a measurement item is "3-essential" and N is the total number of experts on the panel.

Therefore, in this study, N =15. The CVR equation as shown in Equation (1) produces outcome values ranging between -1.00 and +1.00, where a CVR of 0.00 indicates that 50% of the panel rates the item to be essential. Lawshe developed a table indicating the minimum CVR values based on a one-tailed significance test with p=0.05. The CVR value is dependent on the number of experts used to provide ratings as shown in Table 3.2.

Table 3.2 Minimum Values of CVR

Number of Panelists	**Minimum value***
5	0.99
6	0.99
7	0.99
8	0.75
9	0.78
10	0.62
11	0.59
12	0.56
13	0.54
14	0.51
15	**0.49**
20	0.42
25	0.37
30	0.33
35	0.31
40	0.29

(Lawshe, 1975)

The CVR is calculated to indicate whether the item is pertinent to the content validity. As indicated in Table 3.2, a minimum CVR of 0.49 is required when a panel of experts is composed of 15 members. According to Lawshe's table, only items with CVR values higher than 0.49 were retained, and a list of 18 assessment items was finalized for the RLAI.

3.7 Surveys and Responses

3.7.1 First Question

The first question was designed to find out the major objectives for adopting AWA from the experts' view and to see if there were any missing major objectives that should be considered in developing the RLAI. The actual question is provided below in italic font:

Based on the literature review, seven major objectives for adopting alternative workplace arrangements (AWA) are identified. From the list below, using your knowledge and experience, please select THREE important relative advantages (objectives) in adopting any type of AWA.

<Please mark your choices with an X. You can add your own items and mark them >

The responses of the expert panel regarding the first question are summarized in Table 3.3. The three most important objectives of AWA adoption selected by panelists are, "reduced office space costs", "retention/attraction of skilled employees" and "improved productivity". However, the question was not limited to high-tech companies in this survey; therefore, it is worth comparing these answers with the major objectives selected for the actual adoption cases from both the high-tech companies and non-tech

companies in Chapter 4. Additionally, it is assumed that the seven objectives provided in survey question #1 cover all the major objectives that should be included in the RLAI since no other objectives were added by the experts.

Table 3.3 Important Objectives of AWA Adoption Selected by Experts

TBL	Objectives	Total Number of Selection	%
Economic	Retention/attraction of skilled employees	10	22.2%
	Reduced office space costs	12	26.7%
	Improved productivity	8	17.8%
	Reduced turnover and absenteeism	6	13.3%
	Improved customer satisfaction	2	4.4%
Environmental	Reduced traffic congestion and environmental impacts	5	11.1%
Social	Employment opportunities for aging and handicapped people and employee's work-life balance	2	4.4%

3.7.2 Second Question

The second question was designed to rate the validity of each of the assessment indicators under the overcoming level category regarding managerial challenges which stem from the complexity innovation attribute. The question is provided below in italic font:

Complexity is the degree to which an organizational innovation is considered relatively difficult to implement. AWA is a complex organizational innovation and complexity reduces the chance of adoption. Decision makers are still responsible for evaluating their capacity to establish managerial control over AWA to effectively assess their readiness to adopt AWA. Most challenges in adopting AWA are found in managerial issues. According to a three-point scale ("1"= not necessary, "2"=important but not essential, "3"=essential), please rate the validity of these assessment indicators in measuring high-tech companies' initial readiness to adopt AWA

<You can add factors, attributes and assessment indicators as needed>

The responses of the expert panel regarding the second question are summarized in Table 3.4. Out of the five assessment indicators selected through the review of the literature based on the frequency of citations, the supervision indicator and the learning opportunity indicator are rejected because their CVRs are lower than the minimum CVR of 0.49 required as shown in Table 3.4. Therefore, only the three assessment indicators of performance evaluation, coordination and policy/guideline are retained to build up the RLAI.

Table 3.4 Second Question Results

Factors	Attributes	Assessment indicators	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15	CVR
Managerial issues	Performance evaluation	Results-based performance evaluation method in place	3	3	3	3	3	3	3	3	3	2	3	3	3	3	3	**0.87**
	Supervision	A culture of indirect supervision in practice within the organization	2	3	2	3	3	3	3	2	3	2	2	2	3	3	2	**0.07**
	Coordination(Teamwork)	Virtual teamwork in practice within the organization	2	3	2	3	3	3	3	3	3	3	3	3	3	3	3	**0.73**
	Policy/guideline	Clear policy/guideline provision for AWA	3	3	3	3	3	3	3	3	3	2	3	3	3	3	3	**0.87**
	Learning opportunities	Provision of interactive learning opportunities within the organization	3	3	3	3	2	2	3	2	2	2	2	2	3	2	2	**-0.20**

3.7.3 Third Question

The third question was designed to rate the validity of each of the assessment indicators under an appropriate level category stemming from compatibility innovation attributes. The question is provided below in italic font:

Based on the combined insights from the literature review and the answers to the initial survey questions, four factors, attributes, and assessment indicators that will be used to measure the organization's readiness in appropriateness level for adopting AWA are identified and selected as shown below. According to a three-point scale ("1"= not necessary, "2"=important but not essential, "3"=essential), please rate the validity of these assessment indicators in measuring the initial readiness of high-tech companies.

<You can add factors, attributes and assessment indicators as needed>

The responses of the expert panel regarding the third question are summarized in Table 3.5. Again, all assessment indicators were selected through reviews of literature based on the frequency of citations. The CVRs of all three indicators of organizational culture attributes of support, fairness and trust are higher than the minimum. Among the work attributes, all the indicators were retained except one, the concentration indicator. From the employee attributes, the two indicators of effectiveness and communication were rejected since their CVRs were 0.20 and 0.47 respectively. Among the facilities attributes, all three of the indicators, information and communication technology (ICT), premises services and business support services, were retained. All the results from the third survey questions are provided in Table 3.5.

Table 3.5 Third Question Results

Factors	Attributes	Assessment indicators	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15	CVR
Organization	Support	AWA is supported at all levels of organization	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3	0.87
	Fairness	The degree of equal promotional opportunity for distributed workers	3	3	3	3	3	2	3	3	3	3	2	3	3	2	3	0.60
	Trust	The level of trust between managers and their employees	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3	0.87
Work	Type	The level of interaction/communication needed to perform the work	3	3	3	1	3	3	2	3	3	3	3	3	3	3	2	0.60
	Process	The degree of sequential work process vs. reciprocal process	3	3	3	1	3	3	1	3	3	3	3	2	3	3	3	0.60
	Autonomy	The degree of automomy for work	2	3	3	1	3	3	1	3	3	3	3	3	3	3	3	0.60
	Concentration	The need and level of concentration needed to perform the work	2	3	3	1	2	3	1	3	2	3	3	2	3	3	1	0.07
	Delliverables	The level of clarity of defined deliverables	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	1.00
	Physical presence	Required physical presence at the office for work to be able to access specific technology, equipment or live interpersonal response(location dependency)	3	3	2	1	3	3	3	3	3	2	3	3	3	3	3	0.60
Employee	Preference	Employees' level of preference for AWA	3	3	3	3	2	3	2	3	3	3	3	3	3	3	3	0.73
	Sufficiency	Employees' level of self-sufficiency to work	3	3	3	2	3	2	2	3	3	3	3	3	3	3	3	0.60
	Effectiveness	The level of personal effectivenss	2	3	3	1	3	3	2	3	3	1	3	2	3	3	2	0.20
	Communication	Employees' level of communication skills	2	3	3	3	3	2	3	3	3	2	3	3	3	3	2	0.47
	Familiarity	Employees' level of familiarity with ICT	3	3	2	3	3	3	3	3	3	3	3	2	3	3	3	0.73
	Experience	Employees' work experiences with flexible work style	3	3	3	3	3	3	3	3	3	2	3	2	3	3	3	0.73
Facilities	ICT	The provision of ICT support	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	1.00
	Premises services	Building maintenance, cleaning, alternative workplace services, etc	3	3	3	3	2	2	3	2	3	3	3	3	3	3	3	0.60
	Business support services	Utilites, furniture, business equipment, office set-up, etc	3	3	3	3	2	1	3	3	3	3	3	3	3	3	3	0.73

3.8 Readiness Level Assessment Indicators (RLAI)

Organizational readiness assessment needs to be performed to provide decision makers with a reliable, quantifiable assessment of the organization's potential readiness to successfully making the transition to alternative workplaces (Grantham et. al, 2007). Assessment indicators are finally determined by two different stages. First, significant factors, relevant attributes and assessment indicators were initially selected based on combined insights from the literature review and the discussions at the 2008 International Facility Management Association (IFMA) Atlanta Workplace. Next, the validity of the selected assessment indicators was additionally evaluated by the panel of experts formed for this research in order to build the readiness level assessment indicators (RLAI), which measure the initial readiness of high-tech companies for adopting an AWA. The finalized RLAI categories and relevant attributes from which the assessment indictors were extracted are shown in Figure 3.2.

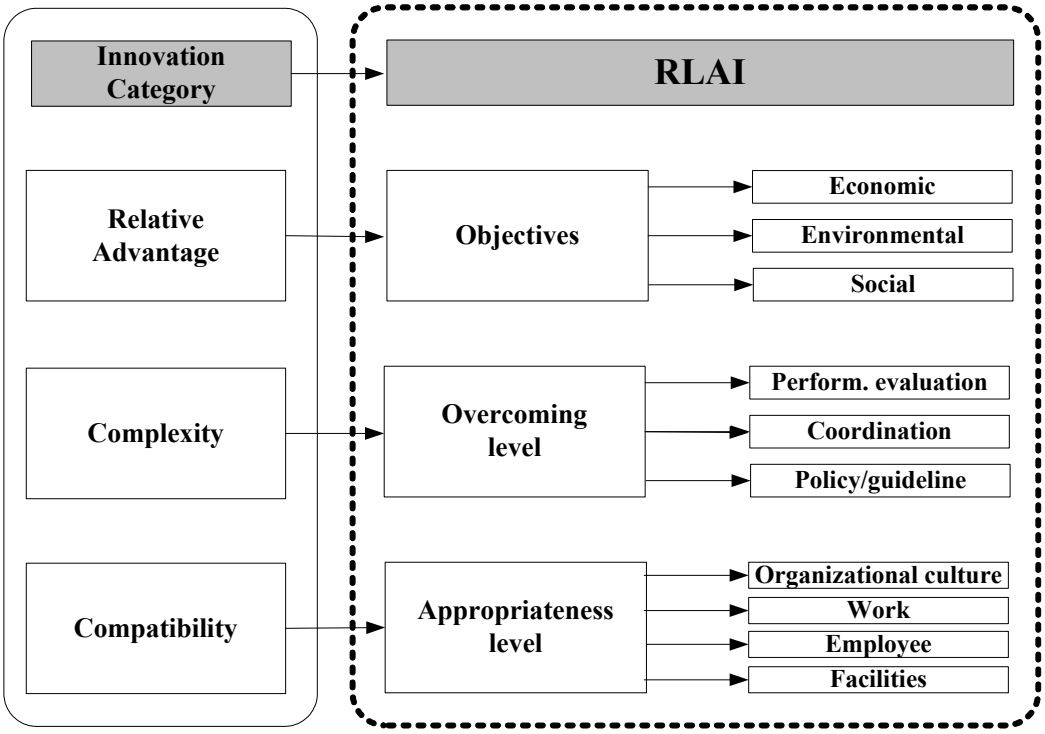


Figure 3.2 Finalized Category of RLAI and Relevant Attributes

3.8.1 Objectives of AWA Adoption

An organization should identify clear objectives for AWA adoption which support the larger /overall goals and objectives of the organization. The triple bottom line (TBL) concept was selected to explore various objectives of AWA adoption from three different perspectives: economic, environmental, and social. Most importantly, the decision makers should be able to select clear objectives from the seven important objectives provided as shown in Table 3.6.

3.8.2 Overcoming Level

From the organizational perspective, most challenges in adopting AWA are found in managerial issues. Established managerial practices can positively influence the success of AWA adoption (Fritz et. al., 1996; Fritz et. al., 1998; Apgar, 1998; Kurland and Bailey, 1999; Cascio, 2000; Felstead et al., 2003; Watad and Will, 2003; Roitz and Jackson, 2006). Therefore, the three assessment indicators of a result-based performance evaluation method, virtual teamwork, and the provision of a clear AWA policy/guideline were used to measure an organization's overcoming level. According to a three point scale ("1"=not exist, "2"=exist but not actively in practice, "3"=exist and actively in practice), users were asked to rate their overcoming levels.

3.8.3 Appropriateness Level

Each indicator measures the appropriateness level by a three point scale ("1"=relatively low, "2"=medium, "3"=relatively high) and there are four factors and relevant attributes in the appropriateness level category as follows:

1. Organization: Support, fairness, and trust
2. Work: Type, process, autonomy, deliverables, and physical presence

3. Employee: Preference, sufficiency, familiarity, and experience
4. Facilities: ICT, premises, and business support services

Table 3.6 RLAI Table

READINESS LEVEL ASSESSMENT INDICATORS(RLAI)							
Innovation Attributes	RLAI category	Factors	Attributes	Assessment indicators	Readubess assessment		
				Have you clearly identified and selected the objectives of the AWA adoption?	Check your objectives		
Relative Advantage	Objectives	Triple Bottom Line(TBL)	Economic	Retention/attraction of skilled employees			
				Reduced office space costs			
				Improved productivity			
				Reduced turnover and absenteeism			
				Improved customer satisfaction			
			Environmental	Reduced traffic congestion and environmental impacts			
			Social	Employment opportunities for aging and handicapped people and employees' work-life balance			
				What is the overcoming level(establishment capacity) for each assessment indicator?	Not exist	Exist but not actively in practice	Exist and actively in pratice
Complexity	Overcoming level	Managerial issues	Performance evaluation	Results-based performance evaluation method in place			
			Coordination(Teamwork)	Virtual teamwork in practice within the organization			
			Policy/guideline	Clear policy/guideline provision for AWA			
				What is the appropriateness level of your company for each assessment indicator?	Relatively low	Medium	Relatively high
Compatibility	Appropriateness level	Organizational culture	Support	AWA is supported at all levels of organization			
			Fairness	The degree of equal promotional opportunity for distributed workers			
			Trust	The level of trust between managers and their employees			
		Work	Type	The level of interaction/communication needed to perform the work			
			Process	The degree of sequential work process vs. reciprocal process (The degree of transactional vs. open ended work process) Close to reciprocal process: 1, close to sequential process: 3, middle or both: 2			
			Autonomy	The degree of autonomy for work(work scheduling, decision prerogatives, etc)			
			Delliverables	The level of clarity of defined deliverables			
			Physical presence	Required physical presence at the office for work to be able to access specific technology, equipment or live interpersonal response(location dependency)			
		Employee	Preference	Employees' level of preference for AWA			
			Sufficiency	Employees' level of self-sufficiency to work			
			Familiarity	Employees' level of familiarity with ICT			
			Experience	Employees' work experiences with flexible work style			
		Facilities	ICT	The provision of ICT support			
			Premises services	Building maintenance, cleaning, alternative workplace services, etc			
			Business support services	Utilites, furniture, business equipment, office set-up, etc			

3.8.4 Appropriateness level for the Facilities Factor

Facility management (FM) is the discipline that improves and supports the productivity of an organization by delivering all the appropriate services needed to achieve the business objectives (CEN/TC 348 FM WG1 2005). FM encompasses a wide range of activities involved in the effective management of built assets. FM has emerged and evolved over the past few decades to better prepare organizations for rapid changes in business, influences of ICT, and the dramatic shifts in requirements for workers focused on knowledge rather than production.

FM is involved in the total management of all services, and it also supports the core business of an organization. Consequently, FM has to perform functions not only to optimize the cost of running a building but also to raise the efficiency and suitability of all management space and other assets for people and processes. Facility management embraces the concepts of cost-effectiveness, productivity improvement, efficiency, and employee quality of life (Cotts 1999).

Compared to other factors such as organization, work, and employees, the facilities factor is the one that can also be used to measure the appropriateness level for adopting an AWA as long as the budget is allowed, this is the only factor that can be easily adjusted to be a better candidate for adopting AWA. The objective of FM is to provide all supporting and enabling internal services needed by the core business at optimized service levels and at optimized costs.

Today, facilities are beginning to be recognized as strategic business resources, and facility managers are becoming recognized as the asset managers commonly responsible for supporting the entire organization. Therefore, it is the facility manager's responsibility to ensure that all services meet the needs of the organization that is adopting an AWA. ICT is becoming increasingly essential for work, and the current level of ICT support is a critical measure for the level of appropriateness of adopting an AWA.

Although data required by employees vary by type of work, work process and worker position, an organization must determine how distributed workers gain access to important data from distributed workplaces. AWA is supported if a number of means of connectivity, such as the Internet, satellite, cable, FTTH, cellular, radio, wireless, and others, are all available for distributed workers, but if the organization does not have the right tools or software protecting its significant data, the level of ICT support should be assessed as poor. Other supports such as premises and business service supports are also taken into account when assessing the appropriateness level. How these support systems are carried out is the responsibility of FM. Not only does an organization need to support the physical work environment, but it must also take care of business support services including the impact of the work environment, such as utilities, furniture, office equipment, noise levels, lighting, rent, and so on. It must also provide technical support for both the primary office, as well as off-site alternative workplaces, if higher productivity and worker satisfaction are expected.

Compared to other factors such as organizational culture, work, and employee, the facilities factor and its attributes such as ICT, premises services, and business support services are relatively easier to adjust to make them more appropriate for adopting AWA.

3.9 The Role of the Facility Manager

Most facility managers have been viewed narrowly as technical facility managers, not as business managers; however, this situation is changing as increasing numbers of companies recognize the value of FM (Cotts, 1999). The responsibilities of facility managers extend beyond operational issues to the more fundamental goals of providing high performing and sustainable workplaces (Kaczmarczyk and Murtough, 2002). Most organizations will be facing uncertainties when adopting an AWA and the facility manager is the one who is going to take an important role as a change-master in order to effectively deal with such changes. Adopting an AWA will force some changes in the way organizations adapt themselves to new workplace environments. As the adoption goes forward, the right person to handle the upcoming changes and needs for the AWA adoption is the facility manager, who is nearly always has a solid understanding of the work, workplace, and people within the organization and regularly measures both the effectiveness and the efficiency of the organization. Facility managers are responsible for developing workplace strategies to meet the organization's current and future needs for the years ahead (McGregor, 2000).

CHAPTER 4

DATA COLLECTION AND ANALYSIS

4.1 Purpose

The purpose of this chapter is to present how AWA adoption cases were collected using the RLAI and to analyze the data to test the hypothesis of this research as shown in Figure 4.1.

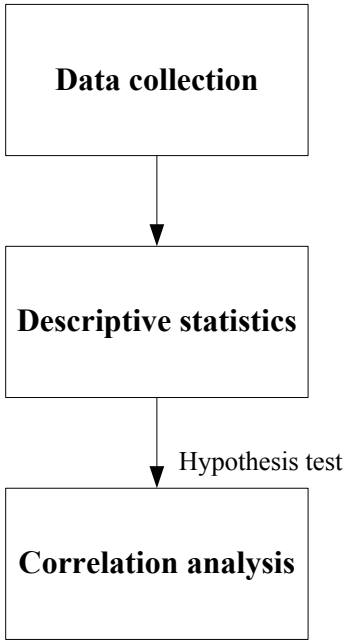


Figure 4.1 Brief Process Diagram

In order to collect data from the industry, the data collection table was prepared based on the RLAI developed in Chapter 3. The RLAI were expected to effectively capture the readiness of the participating organizations for adopting an AWA. Using the RLAI, a total of 64 real adoption cases were collected from 19 large high-tech companies that had already adopted any of the six AWA types: hoteling, group address, shared

office, satellite office, home office, and virtual office. After the rank correlation analysis was conducted, it is concluded that the hypothesis of this research is confirmed.

4.2 Data Collection Table

Based on the RLAI, which are expected to effectively capture the readiness of the organizations for adopting an AWA, the data collection table was prepared. After an initial collection table was developed, pre-testing was also conducted. Collection tables were sent to two companies, and the respondents were asked to fill out the collection table. Questions in the initial table used a five-point scale; however, respondents reported difficulties in filling out the table. Consequently, questions in the table were changed to measure the readiness using a three-point scale rather than a five-point one ("1"=relatively low, "2"=medium, "3=relatively high). More suggestions were obtained from respondents regarding the satisfaction level, and satisfaction level was measured according to a three point scale ('1"=less satisfied, "2"=satisfied, and "3"=highly satisfied). Respondents were asked to generalize the answer (e.g. "Please use what you would consider to be the majority response.") for the situation when employees were viewed as having different levels of preference/self-sufficiency/effectiveness.

Additionally, in order to develop an effective decision model that can predict an appropriate AWA type with the satisfaction level, respondents were asked to try to select only one AWA type even though most companies are employing multiple workplace options to address personal situations, personal preferences, and business and organizational needs. Therefore, when respondents selected more than two AWA types, at first, the author politely asked them to select only one type. However, if respondents were not able to select only one type for their adoption case, their answers were discarded. There are five parts in the collection table. Part one, two, and three were designed to capture the readiness level of the participating companies as the inputs and part four and

five were designed to collect the adoption outputs, in other words, the actual AWA type selected along with the satisfaction level.

4.3 Data Collection

Through telephone interviews, conference calls and email questionnaires, the RLAIs were used to collect a total of 64 real adoption cases from 19 large high-tech companies that had already adopted any of the six AWA types: hoteling, group address, shared office, satellite office, home office, and virtual office. Most of the companies provided more than one adoption cases since most of the cases were documented by different years. The number of cases documented in 2005 is three; in 2006, six; in 2007, eleven; and in 2008, 22. The number of ongoing cases is 22.

A sample of the email sent to collect data and the attached data collection table are shown in Figure 4.2 and Table 4.1 respectively.

Dear Respondents,

Thank you again for your participation on this research.

As explained before, I need to collect data from the organizations that have already adopted

any type of alternative workplace arrangements (AWA). Case data of AWA adoption will be reviewed

for analyzing the relations between variables such as inputs and outputs and for developing decision model

which will allow decision makers to predict an appropriate AWA type along with expected satisfaction level.

Keeping your situation in mind(for example, AWA type adopted for your company along with condtions of

organizational culture, work, employee, and facilities supports, please rate each assessment item and at the end,

please tell me which type has been adopted for you company with the satisfaction level.

When it is hard to generalize your answer (for example, when employees have different level of preference/ self-sufficiency/ experience),

please use the majority of cases. Please fill out your answers in PURPLE cells. If you have any questions, please let me know.

Again, this survey is completely anonymous and the results of this research will be shared with all participants of this research.

Thank you!

Jun Ha Kim, FMP, Ph.D. Candidate

Georgia Institute of Technology

Building Construction Program

Figure 4.2 Sample Email to Collect Data

Table 4.1 Data Collection Table using RLAI

Data collection table			
		Organization	
		Location(country)	
		Industry	
		Job Type	
		Respondent's position	
		Case date	
Factor	**Attributes**	**Assessment indicators**	
Part 1	Please mark top THREE important objectives of AWA adoption for your company with an X		
Triple Bottom Line(TBL)	Economic	Retention/attraction of skilled employees	
		Reduced office space costs	
		Improved productivity	
		Reduced turnover and absenteeism	
		Improved customer satisfaction	
	Environmental	Reduced traffic congestion and environmental impacts	
	Social	Employment opportunities for aging and handicapped people and employees' work-life balance	
Part 2	Please rate each item for your case("1"=if not exist, "2"= if exist but not actively in practice, "3"=if exist and actively in practice)		
Managerial issues	Performance evaluation	Results-based performance evaluation method in place	
	Coordination(Teamwork)	Virtual teamwork in practice within the organization	
	Policy/guideline	Clear policy/guideline provision for AWA	
Part 3	Please rate each item for your case according to three a three-point scale("1"=relatively low, "2"= medium, "3"=relatively high)		
Organizational culture	Support	AWA is supported at all level of organization	
	Fairness	The degree of equal promotional opportunity for distributed workers	
	Trust	The level of trust between managers and their employees	
Work	Type	The level of interaction/communication needed to perform the work	
	Process	The degree of sequetial work process vs. reciprocal process or the degree of transactional vs. open ended work process. ("1"=close to sequential process, "2"= middle or both, "3"=close to sequential process)	
	Autonomy	The degree of autonomy for work(work scheduling, decision prerogatives, etc)	
	Delliverables	The level of clarity of defined deliverables	
	Physical presence	Required physical presence at the office for work to be able to access specific technology, equipment or live interpersonal response(location dependency)	
Employee	Preference	Employees' level of preference for AWA	
	Sufficiency	Employees' level of self-sufficiency to work	
	Familiarity	Employees' level of familiarity with ICT	
	Experience	Employees' work experiences with flexible work style	
Facilities	ICT	The provision of ICT support	
	Premises support services	Building maintenance, cleaning, alternative workplace services, etc	
	Business support services	Utilites, furniture, business equipment, office set-up, etc	
Part 4	Please try to select only ONE type with an X for your case.		
Type selection	**ON-SITE Type**	Hoteling (Reserved or un-reserved free-address)	
		Group address (team space)	
		Shared office (2 people share 1 cube)	
	OFF-SITE Type	Satellite office (owned by your company)	
		Home office	
		Virtual work -working anywhere (hotel, train etc.)	
Part 5	Please rate your overall satisfaction with the adoption ("1"=less satisfied, "2"=satisfied, "3"=highly satisfied)		

4.4 Descriptive Statistics

Descriptive statistics are a useful method to show numbers that summarize a group of data. The data collected are categorical data representing a classification of subjects. The data are collected using RLAI, which measures cases by either an ordinal or nominal scale. The appropriate descriptive statistics are the frequencies. Numerical summaries are not provided because of the nature of the data. More discussion regarding the nature of the data is provided in a later section. Frequency distribution, which is the most basic way to restructure raw data, is calculated to facilitate an understanding of the characteristics of the data collected.

The characteristics of the case data collected from the 19 different high-tech companies are described in Tables 4.2 through 4.5. Table 4.2 describes the sample by location. Just over half of the data were collected from high-tech companies located in the U.S., and just under half was from companies in four other countries as shown in Table 4.2.

Table 4.2 Data Characteristics by Location

Location(country)	N	%
US	33	51.6%
Taiwan	9	14.1%
Japan	5	7.8%
Finland	4	6.3%
Korea	13	20.3%
Total	64	100.0%

The high-tech companies can be classified into eight categories: computers, consumer electronics, engineering, IT, networking, technology, and telecommunication. 40.6% of cases were collected from telecom companies, including the leading telecom companies in the U.S., Finland, and Korea as depicted in Table 4.3.

Table 4.3 Data Characteristics by Industry

Industry	N	%
Computer	8	12.5%
Consumer Electronics	6	9.4%
Engineering	2	3.1%
IT	5	7.8%
Networking	5	7.8%
Technology	12	18.8%
Telecom	26	40.6%
Total	64	100.0%

Nine different job types were identified: clerical, consulting, customer service, finance, HR, IT staff, research, and sales. 18 of the jobs were in sales, representing 28.1% of all the data collected, whereas the 9 jobs related to finance represented 14.1% of the sample as indicated in Table 4.4.

Table 4.4 Data Characteristics by Job Type

Job Type	N	%
Clerical	5	7.8%
Consulting	7	10.9%
Customer service	7	10.9%
Finance	9	14.1%
HR	4	6.3%
IT staff	6	9.4%
Research	8	12.5%
Sales	18	28.1%
Total	64	100.0%

Cases were collected from respondents who currently assess the company's readiness for AWA and/or manage distributed workers. Most importantly, cases were collected from managers who had access to AWA adoption reports so as to provide reliable data for this research. Since middle managers' views are very important and their support is crucial to the successful adoption of AWA (Watad and Will, 2003), the author

tried to contact as many middle managers as possible to collect data. As a result, 57.8% of the cases were ones in which the data was collected from the middle managers, followed by 20.3 % collected from senior managers as shown in Table 4.5.

Table 4.5 Data Characteristics by Respondents' Position

Respondent's position	N	%
Director	5	7.8%
Middle manager	37	57.8%
Senior manager	13	20.3%
Supervisor	9	14.1%
Total	64	100.0%

4.5 Case Description on Objective of AWA Adoption (A1-A7)

In Chapter 3, the panel of experts was asked the same question, and their responses regarding three important objectives in adopting any type of AWA were tabulated and are shown in Table 3.3. However, the question was not limited to high-tech companies. Major objectives of the actual adoption cases from high-tech companies were tabulated as shown Table 4.6, and differences between responses from the experts without focusing on technology companies and the ones from the actual adoption cases from technology companies are identified. The most important objectives of AWA adoption from both experts (26.7%) and actual adoption cases from technology companies (25.5%) are "reduced office space costs". The second most important objectives selected by the experts (22.2%) were "retention/attraction of skilled employees," whereas the second most important objectives selected by the actual cases (25.0%) were "improved productivity."

Finally, the third most important objectives selected by the experts (17.8%) were "improved productivity," whereas the third most important objectives selected by the actual cases (14.6%) were "retention/attraction of skilled employees".

More than half of the technology companies felt that reduced office space costs and improved productivity were important. Therefore, it can be concluded that there is not much difference between selecting general objectives and specific objectives of high-tech companies for AWA adoption. Most technology companies feel that reduced turnover and absenteeism, improved customer satisfaction, reduced traffic congestion and environmental impacts, and employment opportunities for aging and handicapped people and employees' work-life balance (A4-A7) are not important.

Table 4.6 Important Objectives selected by High-Tech Companies

Variables	Important Objectives	High-Tech Companies			
		Not Important (0)		Important (1)	
		N	%	N	%
A1	Retention/attraction	36	14.1%	28	14.6%
A2	Reduced costs	15	5.9%	49	25.5%
A3	Improved productivity	16	6.3%	48	25.0%
A4	Reduced turnover	49	19.1%	15	7.8%
A5	Improved customer satisfaction	44	17.2%	20	10.4%
A6	Environmental	51	19.9%	13	6.8%
A7	Social	45	17.6%	19	9.9%
Total		256	100%	192	100%

4.6 Case Description on Type Selection (Y1) and Satisfaction Level (Y2)

As shown in Table 4.7, among on-site types, hoteling was selected by eleven cases representing 17.2% followed by shared office (14.1%) and group address (12.5%). Among off-site types, satellite office was selected by thirteen cases representing 20.3%, followed by virtual (18.8%) and home office (17.2%). Over 55% of the technology companies allow off-site working situations.

As suggested by respondents in the pre-testing stage, only 20.3% of the cases were categorized as “less satisfied,” and 28.1% of the cases were marked as “satisfied”. More than half of all the cases were categorized as “highly satisfied”. About 80% of all the cases are marked as “satisfied” or above with their satisfaction level, which means that adoption cases collected by RLAI, which is expected to effectively capture the readiness level of the organizations, can represent best practices for AWA adoption.

Table 4.7 Outputs of AWA Adoption

High-tech companies				
Type selection (Y1)			N	%
On-site	Hoteling	1	11	17.2%
	Group address	2	8	12.5%
	Shared office	3	9	14.1%
Off-site	Satellite office	4	13	20.3%
	Home office	5	11	17.2%
	Virtual office	6	12	18.8%
Satisfaction level (Y2)			64	
Satisfaction level	Less Satisfied	1	13	20.3%
	Satisfied	2	18	28.1%
	Highly Satisfied	3	33	51.6%

4.7 Case Description on Readiness Level (X1-X18)

Most of the high-tech companies seemed to have rated the readiness levels, named as X1-X15, "medium." However, a substantial number of companies rated X2, X6, X9, and X13 "relatively high," as shown in Table 4.8. Among managerial issues measuring the establishment capacity of managerial practices, results-based performance evaluation methods and virtual teamwork in practice within the organization exist in most technology companies, but they are not actively in practice. However, most technology companies not only have a clear policy/guideline provision for AWA, but actively follow it.

Table 4.8 Readiness Levels of Adoption Cases

High-tech Companies								
X1-X15			Relatively Low (1)		Medium (2)		Relatively High (3)	
			N	%	N	%	N	%
Organization	Support	X1	7	10.9%	39	60.9%	18	28.1%
	Fairness	X2	7	10.9%	34	53.1%	23	35.9%
	Trust	X3	11	17.2%	42	65.6%	11	17.2%
Work	Type	X4	12	18.8%	42	65.6%	10	15.6%
	Process	X5	11	17.2%	35	54.7%	18	28.1%
	Autonomy	X6	10	15.6%	34	53.1%	20	31.3%
	Deliverables	X7	15	23.4%	31	48.4%	18	28.1%
	Physical presence	X8	25	39.1%	30	46.9%	9	14.1%
Employee	Preference	X9	16	25.0%	23	35.9%	25	39.1%
	Sufficiency	X10	9	14.1%	39	60.9%	16	25.0%
	Familiarity	X11	14	21.9%	32	50.0%	18	28.1%
	Experience	X12	24	37.5%	28	43.8%	12	18.8%
Facilities	ICT	X13	5	7.8%	32	50.0%	27	42.2%
	Premise	X14	17	26.6%	35	54.7%	12	18.8%
	Business	X15	10	15.6%	37	57.8%	17	26.6%
X16-X18			Doesn't Exist (1)		Exist but not Active (2)		Exist and Active (3)	
			N	%	N	%	N	%
Managerial issues	Performance evaluation	X16	12	18.8%	26	40.6%	26	40.6%
	Coordination (Teamwork)	X17	18	28.1%	32	50.0%	14	21.9%
	Policy/guideline	X18	29	45.3%	17	26.6%	18	28.1%

4.8 Discussion of Best Practice Cases

While describing AWA adoption cases collected form high-tech companies, some important features of successful AWA adoption cases were revealed. One is the relatively more important objectives by different AWA type, and the other feature is that there are different readiness levels expressed in appropriateness and overcoming levels as reported for on and off site types.

First, relatively more successful cases were extracted from the case data. Only 33 cases with the satisfaction level "3", highly satisfied with AWA adoption, were selected for more analysis to determine suggested objectives by different AWA types. For each AWA type, the main objectives of each case have been identified based on the higher frequency of selection from the respondents. Table 4.9 summarizes the top three objectives of AWA adoption by type and provides facility managers with an example of an appropriate type given their clearly identified objectives of AWA adoption. According to the frequency of selection, the main objectives for adopting each AWA type are the following:

- **Hoteling**: "reduced office space costs" and "improved productivity"
- **Group address**: "improved productivity" and "reduced turnover and absenteeism"
- **Shared office**: "reduced office space costs" and "employee's work-life balance"
- **Satellite office**: "improved productivity" and "improved customer satisfaction"
- **Home office**: "reduced office space costs" and "improved customer satisfaction"

- **Virtual office**: “reduced office space costs” and “improved customer satisfaction”

Next, the average overcoming levels were calculated from successful cases to compare differences in overcoming levels between on-site and off-site types. Among three overcoming measurement areas, levels of off-site types are higher than the ones of on-site types in all three areas as shown in Table 4.10.

This confirms the previous research findings (Kurland and Bailey, 1999) that managerial challenges become greater as distributed workers are further from the central office in terms of physical distance so that higher overcoming levels are needed for successful AWA adoption as shown in Figure 4.3.

Finally, the average appropriateness levels were calculated from successful cases to compare differences in the levels between on-site and off-site types. Among the 15 appropriateness measurement areas, levels of off-site types indicate higher than the ones for on-site types in 11 areas as shown in Table 4.11. However, the appropriate levels for on-site types found to be higher in four areas are as follows (see Figure 4.4):

- The level of interaction/communication needed to perform the work
- The degree of sequential work process vs. reciprocal process (The degree of transactional vs. open ended work process) “close to reciprocal process”: 1, “close to sequential process”: 3, “middle or both”: 2
- Required physical presence at the office for worker to be able to access specific technology, equipment or live interpersonal response (location dependency)
- The level of premise supports

The areas in which obvious distinctions between on-site and off-site types are revealed are work types, process and physical presence. These attributes are all under "work" factor. This indicates that the level of interaction needed to perform the work and the level of required physical presence at the office are found to be lower in off-site types. Surprisingly, sequential work processes are found more in on-site types, whereas it was assumed that sequential work processes would be found more in off-site types. This indicates that work process is not a critical attribute in selecting an appropriate AWA type because work process itself doesn't seem to be a significant issue anymore with the development of sophisticated ICT.

Table 4.9 Top Two Objectives selected by different AWA Type

AWA motivation category	Objectives	Main objectives selected by type					
		On-site type			Off-site type		
		Hoteling	Group address	Shared office	Satellite office	Home office	Virtual office
Economic	Retention/attraction of skilled employees	X				X	
	Reduced office space costs	X		X		X	X
	Improved productivity	X	X	X	X	X	X
	Reduced turnover and absenteeism		X		X		
	Improved customer satisfaction		X		X		X
Environmental	Reduced traffic congestion and environmental impacts						
Social	Employment opportunities for aging and handicapped people and employee's work-life balance			X			

Table 4.10 Average Overcoming Levels by Different AWA Types

Overcoming Levels	AWA Type	
	On-site AWA	Off-site AWA
Results-based performance evaluation method in place	1.75	2.62
Virtual teamwork in practice within the organization	1.67	2.57
Clear policy/guideline provision for AWA	1.50	2.71

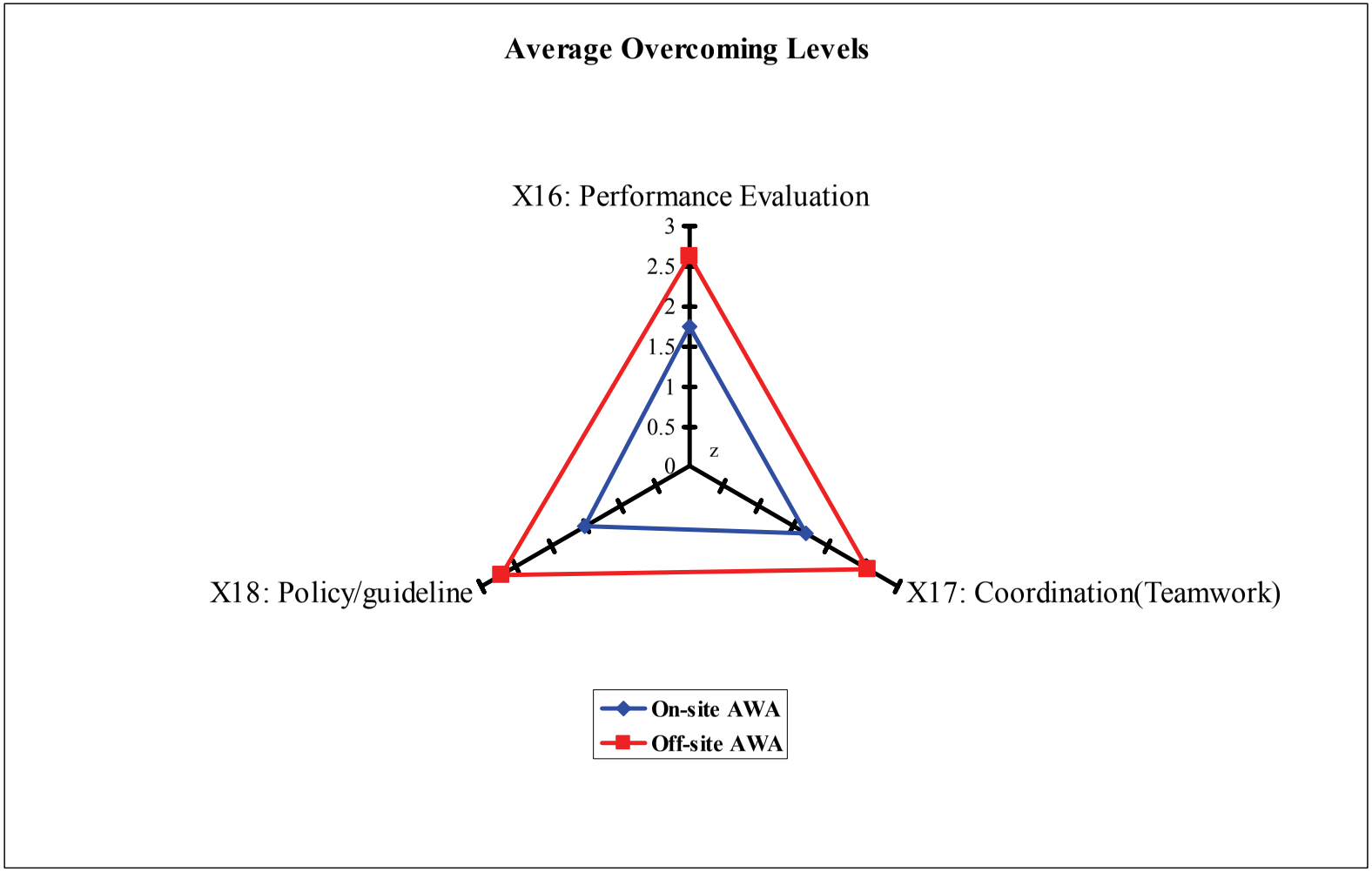


Figure 4.3 Overcoming Level Comparison between Different AWA Types

Table 4.11 Average Appropriateness Levels by different AWA Types

Appropriateness Levels	AWA Type	
	On-site AWA	Off-site AWA
AWA is supported at all levels of organization	2.33	2.52
The degree of equal promotional opportunity for distributed workers	2.17	2.67
The level of trust between managers and their employees	2.17	2.38
The level of interaction/communication needed to perform the work	2.42	1.67
The degree of sequential work process vs. reciprocal process (The degree of transactional vs. open ended work process)Close to reciprocal process: 1, close to sequential process: 3, middle or both: 2	2.58	1.95
The degree of autonomy for work(work scheduling, decision prerogatives, etc)	2.00	2.71
The level of clarity of defined deliverables	2.08	2.57
Required physical presence at the office for work to be able to access specific technology, equipment or live interpersonal response(location dependency)	2.17	1.48
Employees' level of preference for AWA	1.75	2.86
Employees' level of self-sufficiency to work	1.92	2.52
Employees' level of familiarity with ICT	1.75	2.62
Employees' work experiences with flexible work style	1.67	2.48
The provision of ICT support	2.67	2.76
The level of premise supports	2.25	2.00
The level of business support services	2.25	2.62

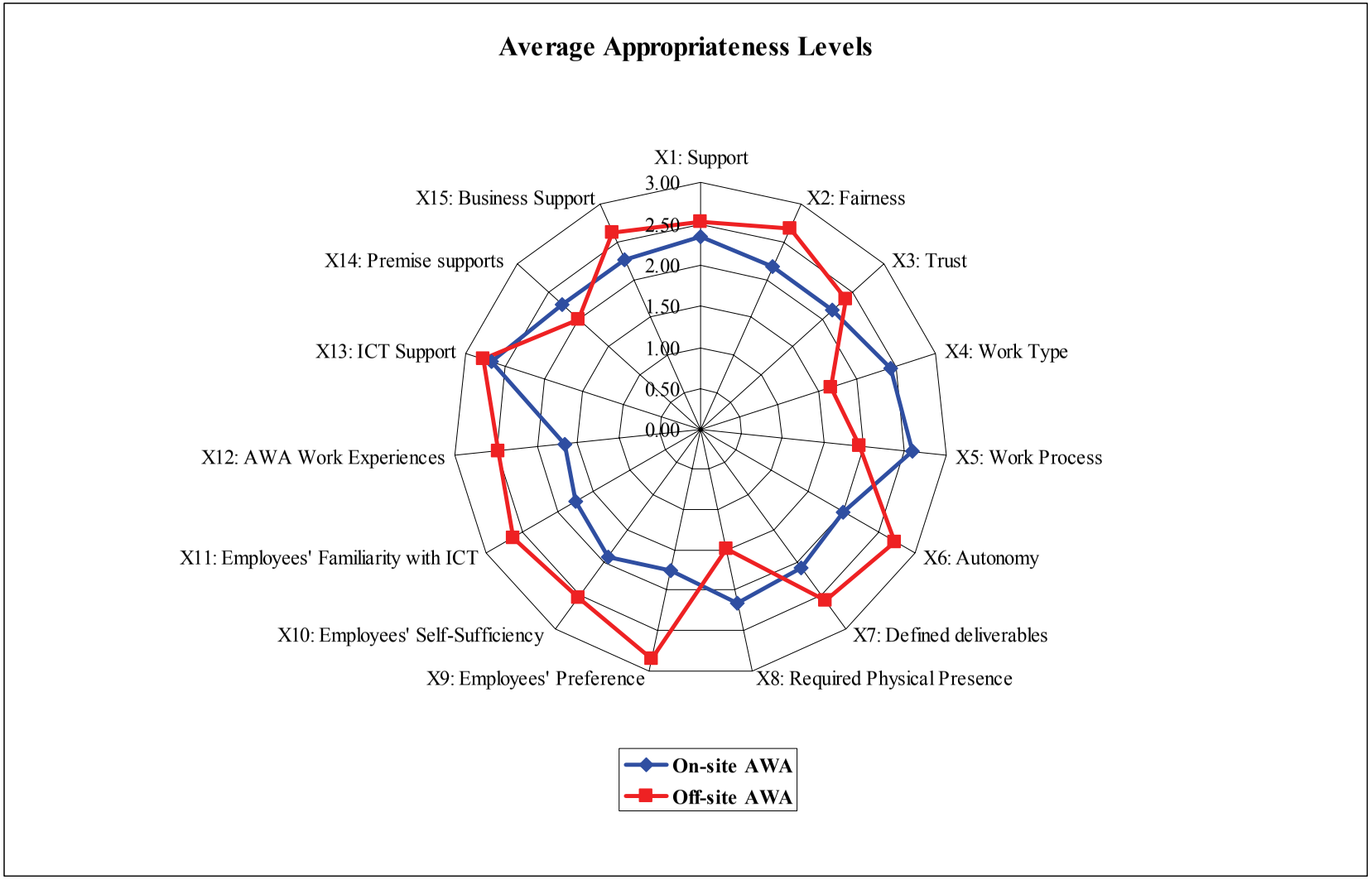


Figure 4.4 Appropriateness Level Comparison between Different AWA Types

4.9 Nature of Data

The type of measuring scale used to collect the data determines the type of statistical tests that can be carried out on the data. Thus, it is critical to review the nature of the data before selecting an appropriate analysis method in statistics because there are techniques for which the distinction is very important. There are four types of scales or levels of measurement: nominal, ordinal, interval and ratio scales (Stevens, 1946).

Nominal data consist of named categories with no implied order among them, and they can be coded by levels (e.g. male=1, female=2). However, they have no quantitative value. Ordinal data consist of ordered categories, and the differences between categories are not equal. The coding has more meaning than nominal data (e.g. less satisfied=1, satisfied=2, highly satisfied=3), however, the distance between the values is not constant. Interval data have equal distances between the values, and the differences between the values are meaningful (e.g. IQ scores); however, the ratios between them do not stay the same. Finally, ratio data are continuous data for which both differences and ratios are interpretable and have a meaningful zero point (e.g. height, weight, etc) as shown in Table 4.12.

Table 4.12 Data Type Distinctions

Data type	Assumptions
Nominal	Named categories
Ordinal	Named and ordered categories
Interval	Ordered categories and equal interval
Ratio	Equal interval with meaningful zero

4.9.1 Nominal Data Collected (A1-A7 and Y1)

Seven objectives of AWA adoption are denoted as A1-A7. For each case, the top three objectives were captured; however, it was not determined which one must be first, second or third for the reason that it is very hard for decision makers to determine the order of importance. Therefore, as for A1-A7, this is not ordinal data but nominal data, which can then easily be turned into a binary variable. For each case, it was determined whether a particular objective was marked or not. If so, it was coded 1; if not it was coded 0.

The six different AWA types selected are denoted as Y1: "1"=hoteling, "2"=group address, "3"=shared office, "4"=satellite office, "5"=home office and "6"=virtual office. The variables in Y1 are nominal data with six levels, where "4"-satellite office is not greater than "1"-hoteling.

4.9.2 Ordinal Data Collected (X1-X18 and Y2)

The readiness levels measured by the 18 different indicators are denoted as X1-X18. The X variables are ordinal data with three levels, and they were collected using a three point scale ("1"=relatively low, "2"=medium, "3=relatively high).

The satisfaction levels were measured according to a three point scale ('1"=less satisfied, "2"=satisfied, and "3"=highly satisfied) and denoted as Y2. They are clearly ordinal data with three levels.

4.10 Correlation Analysis

A correlation, which is a measure of the extent to which two variables are linearly related, is one of the most common and useful statistics and (Miles and Shevlin, 2001). The simplest relationship between two variables is called a linear relationship. When two variables are correlated, if we plot the points on a graph, they will show a straight line, which is usually referred to as the regression line. However, we are unlikely to find that our data points lie exactly on a straight line. Therefore, we need to explain the term, "error," which arises from random factors. The equation of a straight line is commonly defined as shown in Equation 4.1:

$$Y = aX + b + error \qquad (4.1)$$

in which X and Y are the variables, with *a*, the slope of line and *b*, the constant.

When high values of one variable are associated with high values of another variable, it is concluded that the correlation is positive, whereas when low values of one variable are associated with high values of another variable, it is concluded that the correlation is negative. A strong correlation means that there is only a small amount of error and most of the points lie close to the regression line, whereas a weak correlation indicates that there is a lot of error and the points are more scattered (Miles and Shevlin, 2001). To determine the strength of the association between variables, some guidance has been provided by Cohen (1988), who has defined a small correlation as having a value of 0.1, a medium correlation as having a value of 0.3 and a large correlation as having a value of 0.5 or greater.

The hypothesis of this research is as follows:

H: A positive rank correlation exists between organizational readiness level for AWA adoption and organization's satisfaction with AWA.

In order to test this hypothesis, correlation analysis was selected because the correlation coefficient measures the strength of any association between a pair of variables (Ling and Liu, 2004). The correlation is measured on a scale ranging from -1, indicating a perfect negative correlation, to +1 indicating a perfect positive correlation, with 0, representing either "no relationship" or "no correlation."

The most common correlation coefficient is the Pearson, but it assumes the following (Hinton et. al., 2004):

- Linear relationship between variables
- The points on a graph are evenly distributed along the straight line
- The data are normally distributed
- The data must be interval or ratio

However, both the readiness level of AWA adoption (Xs) and the satisfaction level (Y2) are ordinal data with three levels, and additionally, it is assumed that the relationship between the variables is not linear. Therefore, Spearman's correlation and Kendall's correlation methods are selected.

4.10.1 Non-parametric Correlation Analysis

Pearson correlation analysis was not selected because the assumptions for using Pearson are violated and nonparametric methods are most appropriate when the sample sizes are small (Hinton et. al., 2004). Alternatively, Spearman's *rho* and Kendall's *tau-b* can be used when one or both variables are not measured on an interval scale, when the

data are not normally distributed, and when the relationship between variables is non-linear. When the association is expected to be non-linear, the relationship can be transformed into a linear form by taking the ranks of the variables rather than using their actual values.

The readiness level denoted as X1-X18 and the satisfaction level denoted as Y2 are ordinal data with three levels respectively. Between the Spearman rank correlation and the Kendall correlation, one is not necessarily better than the other. They just give different ways to look at the data.

When ranks rather than actual values are used, two new variables are created. Spearman's coefficient of rank correlation, denoted by *rho*, can be calculated as follows:

$$rho = 1 - \frac{6\sum d_i^2}{n(n^2 - 1)} \qquad (4.2)$$

where d_i is the difference in the ranks assigned to the two variables (X_i and Y_i) and n is the number of variables in each data set.

Spearman's rank correlation uses the same equation as the Pearson correlation; however, it takes the ranks instead of the actual data. Thus, Spearman's correlation can be selected for a non-linear relationship. Equation 4.2 can be used when a few tied ranks exist in the data set because it still provides a relatively good approximation (Corden and Foreman, 2009).

The Kendall rank correlation is another method for nonparametric correlation. The Kendall correlation also measures the association between two ordinal variables and takes tied ranks into account. Therefore, it is useful for small data sets with a large number of tied ranks (Kruskal, 1958). Kendall's coefficient evaluates how well the rank ordering on the first variable matches the rank ordering on the second variable. Kendall's

tau-b examines each pair of ranks on the second variable. Kendall's coefficient of rank correlation, denoted by *tau-b*, can be calculated as follows:

$$tau - b = \frac{n_c - n_d}{\frac{1}{2} n(n-1)} \tag{4.3}$$

where n_c is the number of concordant pairs and n_d is the number of discordant pairs in the data set.

Table 4.13 Association with Satisfaction Variable (Y2)

IV	Association with Satisfaction Level Variable (Y2)	Spearman's rho	Kendall's tau-b	P-value		Significance level		
				Spearman	Kendall	90%	95%	99%
X1	Support	0.531**	0.493	0.000	0.000	Yes	Yes	Yes
X2	Fairness	0.404**	0.374	0.001	0.001	Yes	Yes	Yes
X3	Trust	0.599**	0.558	0.000	0.000	Yes	Yes	Yes
X4	Type	-0.077	-0.073	0.546	0.568	No	No	No
X5	Process	0.170	0.161	0.180	0.193	No	No	No
X6	Autonomy	0.475**	0.434	0.000	0.000	Yes	Yes	Yes
X7	Deliverables	0.528**	0.486	0.000	0.000	Yes	Yes	Yes
X8	Physical presence	-0.055	-0.047	0.668	0.707	No	No	No
X9	Preference	0.455**	0.413	0.000	0.000	Yes	Yes	Yes
X10	Sufficiency	0.331**	0.304	0.008	0.004	Yes	Yes	Yes
X11	Familiarity	0.405**	0.374	0.001	0.000	Yes	Yes	Yes
X12	Experience	0.586**	0.550	0.000	0.000	Yes	Yes	Yes
X13	ICT	0.666**	0.620	0.000	0.000	Yes	Yes	Yes
X14	Premise	0.240	0.220	0.056	0.053	Yes	No	No
X15	Business	0.647**	0.610	0.000	0.000	Yes	Yes	Yes
X16	Performance evaluation	0.147	0.132	0.245	0.260	No	No	No
X17	Coordination(Teamwork)	0.482**	0.445	0.000	0.000	Yes	Yes	Yes
X18	Policy/guideline	0.565**	0.512	0.000	0.000	Yes	Yes	Yes

**. Correlation is significant at the .01 level (2-tailed).

4.10.2 Rank Correlation Analysis Results

Rank correlation analysis was conducted to measure the association between two ordinal variables: the readiness level and the satisfaction level, as indicated in Table 4.10. Two rank correlations, Spearman's and Kendall's, showed similar results as shown in Figure 4.2. Therefore, Spearman's *rho* was selected to interpret the results of rank correlation between the readiness level and the satisfaction level.

Hypothesis testing was used to make a conclusion about a population using data obtained from a sample. A hypothesis is a statement that can be either proved or disproved. According to Weiss (1999), there are steps needed to hypothesis testing:

- Formulate the hypothesis
- Identify a statistical method that can be used to measure the truth of the hypothesis
- Determine the p-value and compare it to an acceptable significant value

As suggested by Weiss (1999), the three steps this research has taken are as follows:

- First, the hypothesis of this research is formulated as follows:

H: A positive rank correlation exists between organizational readiness level for AWA adoption and organization's satisfaction with AWA

- Next, statistical methods are identified, ie. Spearman and Kendall's rank correlation analysis.
- Finally, correlation analysis was conducted and the results are obtained as shown in Table 4.10.

When considering the predictor variables independently, the results indicate that there are many variables measuring the readiness level, denoted as Xs, which are positively correlated with the satisfaction level, denoted as Y2.

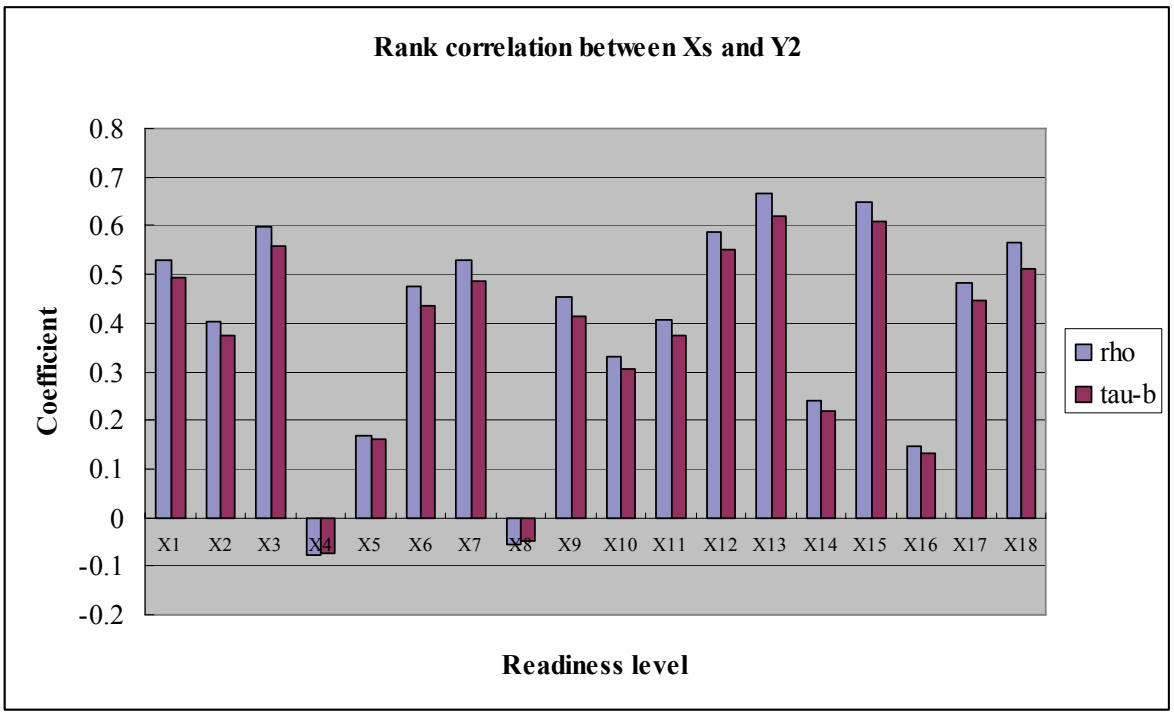


Figure 4.5 Spearman and Kendall's Correlation between Xs and Y2

Among the 18 variables measuring the readiness level for each case, the following 16 variables are positively correlated with the organization's satisfaction level with AWA adoption as depicted in Figure 4.2.

X1: The level of AWA supported at all levels of the organization

X2: The degree of equal promotional opportunity for distributed workers

X3: The level of trust between managers and their employees

X5: The degree of sequential work process vs reciprocal process

X6: The degree of autonomy for work

X7: The level of clarity of defined deliverables

X9: Employees' level of preference for AWA

X10: Employees' level of self-sufficiency to work

X11: Employees' level of familiarity with ICT

X12: Employees' work experiences with flexible work style

X13: The provision of ICT support

X14: The level of premises support services

X15: The level of business support services

X16: Result-based performance evaluation method in practice

X17: Virtual teamwork in practice within the organization

X18: Clear policy/guideline provision for AWA

Among the 16 variables showing a positive correlation with Y2, 13 of them are significant at the .01 level (99% level) for a two-tailed prediction. Assuming that X4 and X8 are less significant variables measuring the readiness, it is concluded that the hypothesis of this research is confirmed:

H: A positive rank correlation exists between organizational readiness level for AWA adoption and organization's satisfaction with AWA.

Additionally, it was also revealed during the correlation analysis that 18 variables measuring the readiness level are highly correlated as shown in Table 4.14. Therefore, first, it was decided to use all of the X variables to develop the decision model in Chapter 5 because 89 % of all the predictor variables show a positive correlation with Y2, next, high correlations among X variables will be considered when selecting an appropriate modeling techniques.

Table 4.14 Correlations among Variables Measuring the Readiness

IV	Correlation	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14	x15	x16	x17	x18
x1	Spearman's rho		0.330	0.628	-0.116	0.108	0.399	0.561	-0.429	0.494	0.388	0.492	0.535	0.592	-0.025	0.533	0.491	0.550	0.565
x2	Spearman's rho	0.330		0.466	0.041	0.152	0.462	0.503	-0.259	0.513	0.460	0.669	0.434	0.360	0.135	0.369	0.469	0.598	0.414
x3	Spearman's rho	0.628	0.466		0.043	0.218	0.442	0.410	-0.230	0.342	0.405	0.456	0.471	0.440	-0.008	0.494	0.350	0.567	0.439
x4	Spearman's rho	-0.116	0.041	0.043		0.489	-0.132	-0.149	0.508	-0.249	-0.036	-0.036	-0.276	-0.094	0.346	-0.167	-0.079	-0.270	-0.415
x5	Spearman's rho	0.108	0.152	0.218	0.489		0.109	-0.012	0.263	-0.100	-0.017	0.151	-0.041	0.294	0.074	0.152	-0.005	-0.046	-0.071
x6	Spearman's rho	0.399	0.462	0.442	-0.132	0.109		0.547	-0.271	0.553	0.534	0.524	0.582	0.442	0.061	0.420	0.405	0.564	0.660
x7	Spearman's rho	0.561	0.503	0.410	-0.149	-0.012	0.547		-0.309	0.469	0.489	0.486	0.451	0.338	0.228	0.527	0.335	0.437	0.500
x8	Spearman's rho	-0.429	-0.259	-0.230	0.508	0.263	-0.271	-0.309		-0.294	-0.218	-0.298	-0.240	-0.178	0.231	-0.230	-0.326	-0.469	-0.404
x9	Spearman's rho	0.494	0.513	0.342	-0.249	-0.100	0.553	0.469	-0.294		0.505	0.655	0.685	0.519	0.059	0.555	0.661	0.666	0.760
x10	Spearman's rho	0.388	0.460	0.405	-0.036	-0.017	0.534	0.489	-0.218	0.505		0.559	0.557	0.246	0.047	0.384	0.569	0.523	0.480
x11	Spearman's rho	0.492	0.669	0.456	-0.036	0.151	0.524	0.486	-0.298	0.655	0.559		0.487	0.452	0.094	0.467	0.665	0.670	0.569
x12	Spearman's rho	0.535	0.434	0.471	-0.276	-0.041	0.582	0.451	-0.240	0.685	0.557	0.487		0.581	0.025	0.614	0.485	0.707	0.709
x13	Spearman's rho	0.592	0.360	0.440	-0.094	0.294	0.442	0.338	-0.178	0.519	0.246	0.452	0.581		0.082	0.538	0.240	0.495	0.583
x14	Spearman's rho	-0.025	0.135	-0.008	0.346	0.074	0.061	0.228	0.231	0.059	0.047	0.094	0.025	0.082		0.266	-0.060	-0.087	-0.015
x15	Spearman's rho	0.533	0.369	0.494	-0.167	0.152	0.420	0.527	-0.230	0.555	0.384	0.467	0.614	0.538	0.266		0.291	0.541	0.544
x16	Spearman's rho	0.491	0.469	0.350	-0.079	-0.005	0.405	0.335	-0.326	0.661	0.569	0.665	0.485	0.240	-0.060	0.291		0.504	0.462
x17	Spearman's rho	0.550	0.598	0.567	-0.270	-0.046	0.564	0.437	-0.469	0.666	0.523	0.670	0.707	0.495	-0.087	0.541	0.504		0.714
x18	Spearman's rho	0.565	0.414	0.439	-0.415	-0.071	0.660	0.500	-0.404	0.760	0.480	0.569	0.709	0.583	-0.015	0.544	0.462	0.714	

Note:
1. Cells in orange show the correlation coefficients (>.4) that are significant at the .01 level (2-tailed).
2. Out of 306 cells, 92 cells show the correlation coefficients (>.5) yielding 30.07% and 160 cells show the correlation coefficients (>.4) yielding 52.29%.

CHAPTER 5

DECISION SUPPORT MODEL DEVELOPMENT

5.1 Purpose

One of the main objectives of this research is to develop an AWA decision support model that allows decision makers to predict an appropriate AWA type along with the expected satisfaction level.

The data mining concept is becoming increasingly popular as a business decision making tool due to its robust prediction ability. Data mining is the process of analyzing and summarizing data into useful information for the decision maker. The most common type of data mining is predictive data mining, which has the most direct applications for business decision making and is commonly used to predict some business interests (Han and Kamber, 2001). The goal of predictive data mining is to identify a statistical or artificial neural network model that can be used to predict outcomes (Hill and Lewicki, 2007).

Therefore, an artificial neural network (ANN) based decision support model was developed. Among the many types of ANNs, a backpropagation was selected to construct the ANN model. In the domain of ANNs, a backpropagation is one of the most important ANN paradigms because it is reasonably simple to implement and works extremely well for a wide variety of applications.

To validate the selected model's predictive performance, case-based reasoning(CBR), which is a problem solving technique in which past cases and experiences are re-used to find a solution to particular problems(Shin and Han, 2001), was used. Figure 5.1 shows a quick overview of which modeling techniques were used to develop the decision support model.

Figure 5.1 briefly illustrates how the decision support model for AWA adoption is developed and validated. Using ANN, a predictive data mining technique, a decision support model is developed to help facility managers predict an appropriate AWA type and anticipated satisfaction level given the organization's objectives and readiness level. The predictive performance of the ANN model is validated using the testing data set, and it is found to be robust enough to predict outputs. As the second model validation effort, a case-based reasoning (CBR) model is also developed to compare its prediction accuracy with that of the ANN decision model. The result of the second validation indicates that the ANN decision model is more effective at predicting the outputs.

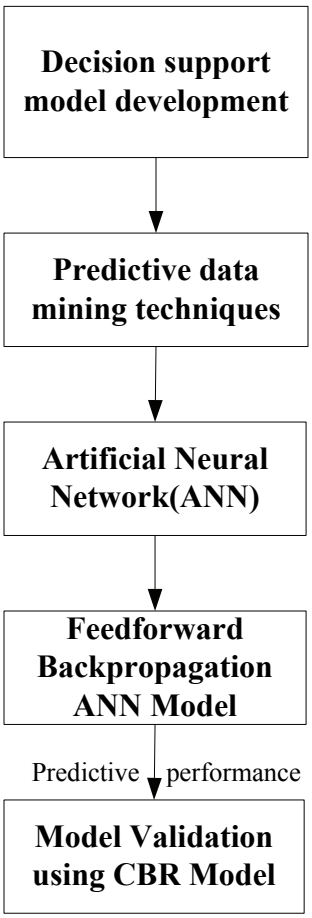


Figure 5.1 Modeling Techniques

5.2 Data Mining

Data mining refers to mining or extracting knowledge from data. There are many other terms implying a similar meaning to data mining such as knowledge mining, knowledge extracting and data or pattern analysis (Han and Kamber, 2001). Data mining involves an integration of techniques from various disciplines such as database technology, statistics, pattern recognition, artificial neural networks, and spatial data analysis (Berry and Linoff, 2000). Data mining is based on the conceptual principles of exploratory data analysis (EDA). The goal of EDA is to explore data (Hand et. al., 2001). The difference between data mining and EDA is that data mining is relatively less concerned with identifying the specific relationships between variables. Thus, data mining, especially predictive data mining, even accepts a "black box" approach (Hill and Lewicki, 2007). Using a black box approach, it is possible to empirically determine a model of the system by entering inputs and checking what the outputs are. ANN is a good example of a "black box" approach which yields accurate prediction results, but can not identify the specific relationships on which the predictions are based.

5.2.1 Predictive Data Mining

The most common type of data mining is predictive data mining, which has the most direct applications for business decision making and is commonly used to predict some business interests (Han and Kamber, 2001). Predictive data mining combines data analysis with statistics and artificial intelligence. It has become an essential tool for decision making in recent years. Thus, many companies are embracing predictive data mining to predict customer behavior and to make decisions based on historical data. In order to use predictive data mining, samples of cases with known answers should be prepared. Successful data mining requires experiments to find a better model based on predictive performance or other desirable solutions (Berry and Linoff, 2000).

Predictive data mining is categorized into types of tasks that correspond to different objectives for the researcher analyzing the data. Predictive data mining is usually involved with different tasks such as regression, prediction and classification (Fayyad et. al., 1996). There are many different types of regression techniques to find a function which models the data with the least error. For prediction tasks, common techniques to develop a model include an artificial neural network (ANN). For classification tasks, techniques include genetic algorithms, fuzzy set approaches and case-based reasoning (CBR).

Regression methods such as linear and nonlinear models are frequently used in the field of predictive data mining. Many nonlinear problems in the business world can be converted to linear problems by performing transformations on the independent variables. Regression models and classification models are similar. The difference between them is that regression models usually deal with continuous output variables (response variables or predicted variables) whereas classification models normally deal with categorical output variables (Hand et. al., 2001). Therefore, when the output variables contain continuous values, regression models are better; however, when the output variables contain categorical values, classification models are better (Miles and Shevlin, 2001).

The regression method was abandoned in developing the decision model because of the following reasons.

- Typically, regressions are not very useful for a small sample data. When doing regression, the cases-to-independent variables ratio should ideally be 20:1, which means 20 cases for every independent variable. The lowest acceptable ratio should be 5:1. This means there should be five cases for every independent variable in the model (Tabachnick and

Fidell, 1989). Only 64 cases were collected for this research and it was decided to use 25 variables, including objectives variables (A1-A7) and readiness variables (X1-X18) for modeling. Therefore, 125 cases would have been needed to develop a regression model.

- When the output variables contain continuous values, regression models are better; however, when the output variables contain categorical values, classification models are better (Miles and Shevlin, 2001). There are two dependent variables that are categorical values in each case: Y1, which denotes the AWA type, and Y2, which denotes the satisfaction level. Y1 is a nominal value with six levels, and Y2 is an ordinal value with three levels.

- Regression can be run only with one response variable at a time. As a result, there is no way to run a regression to predict outcomes of both Y1 and Y2 at the same time. In other words, type selection and satisfaction cannot be investigated at the same time. This is a severe limitation of regression.

Therefore, among three different tasks involved in predictive data mining, only prediction and classification tasks were selected for developing and validating the decision model. For the prediction task, artificial neural networks (ANNs) were used to develop a decision support model. Among the many types of ANN, a backpropagation network (BPN) was selected to construct the ANN model. To validate the ANN based decision model, case-based reasoning(CBR), which is a problem solving technique in which past cases and experiences are re-used to find a solution to particular

problems(Shin and Han, 2001), was used to compare the two models' predictive performance.

5.3 Artificial Neural Network (ANN)

ANN is a widely used predictive data mining technique. It is a directed graph composed of nodes, which are sometimes referred to as units or neurons, and connections between the nodes (Zeidenberg, 1990). The human brain is composed of a very large number of neurons that are massively interconnected. ANN is a simplified model of the human brain, and it mimics the human brain by learning knowledge and storing learned knowledge within neuron connection weights (Giudici, 2003). Over the last few years, the artificial neural network (ANN) methodology has been accepted widely to solve problems in business, and ANN has become one of the most highly parameterized models that has attracted considerable attention in recent years (Hand et. al., 2001).

ANN is often introduced when there are problems of prediction, classification or control for several reasons. The first reason is that Ann's level of sophistication. Even though linear modeling has been used commonly in various modeling domains due to the fact that linear models have well-known optimization strategies (Hill and Lewicki, 2007), there are many real business situations where the linear modeling approach is not valid or appropriate, for example, when it is necessary to derive meaning from complicated or imprecise data. ANN is a very sophisticated modeling technique that is capable of modeling complex functions and can be used to extract patterns and detect trends that are too complex to be noticed by linear modeling (Hill and Lewicki, 2007). With advances in the technology of ANN, it is possible to successfully develop nonlinear ANN models to examine different processes and relationships between input and output variables.

The second reason to apply ANN is that ANN modeling is relatively easier than other traditional nonlinear statistical methods. Additionally, it is very crucial to note that ANN can learn by example. ANN has an ability to automatically learn how to do tasks

based on the input data given by using training algorithms. Even though it is always preferred that the users have some knowledge of how to collect and prepare data, how to select an appropriate ANN, and how to interpret the results, the level of heuristic knowledge required to develop an ANN model is much lower for users compared to other modeling methods. Therefore, if the research needs to consider a relationship between inputs and outputs, it is possible to develop an ANN model even if the expected relationship is noisy (Hill and Lewicki, 2007). ANN is able to extract nonlinear models from observed data sets and easily generate predictions, even more easily than nonlinear regression methods.

In addition, one of the major attractive characteristics of ANN is generalization, which is the ability to use information that ANN has gathered during the learning period to synthesize input-output mapping with new data (Radonja and Stankovic, 2002).

5.3.1 The Basic Architecture of Artificial Neural Network (ANN)

There should be input and output data to build up an ANN model. In statistics, input data are called independent variables or predictor variables, and output data are called dependent variables or predicted variables. A very important issue in any ANN modeling is how the neurons should be connected together since, in an ANN model, there can be hidden neurons between input and output data.

In ANN modeling procedure, the input, hidden and output neurons are connected together. Figure 5.2 describes the feedforward architecture of an ANN model. The arrow at the bottom shows the information flow from input neurons, through hidden neurons, finally reaching the output neurons. All three layers are connected in the ANN structure. However, the input layers play only the role of introducing the values of the input variables, whereas the hidden and the output layers play an active role in computations (Stalinski and Tuluca, 2006).

Users can define ANN that is partially connected to only some neurons in the preceding layer, but a fully connected ANN is better for most applications and also the feedforward has been proved to be the most useful in solving real business problems (Hill and Lewicki, 2007).

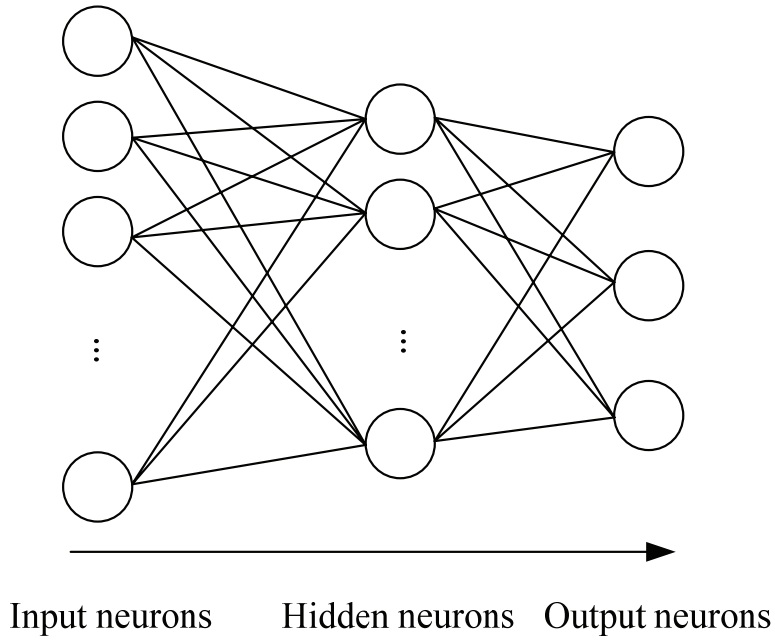


Figure 5.2 Feedforward Architecture of ANN

5.3.2 Learning Algorithm

Learning in an ANN occurs typically by adjustment of the weights. The ANN is trained either to complete an input pattern, classify an input pattern, or compute a function of its input data. There are supervised and unsupervised learning algorithms, but supervised learning is the most common algorithm for ANN modeling (Hill and Lewicki, 2007). An error back-propagation is a supervised learning method developed by Rumelhart et. al. (1986) to compare the responses of the output values to the desired values and to readjust the weights in the ANN so that the next time, when the same input

is presented to the ANN, the ANN's response will be closer to the desired values. An error back-propagation is simply called a backpropagation, which is the most useful learning method for the feedforward ANN (Zeidenberg, 1990).

Once the inputs and outputs of the training data are entered into the system, ANN compares the generated output to the actual output from the training data. Then it calculates the error in each output neuron. For each neuron, ANN calculates what the output should have been: ANN determines how much lower or higher the output must be adjusted to match the actual output stored in testing cases. The differences between the generated output and the actual output are expressed in the local error, and ANN continuously adjusts the weights of each neuron to lower the local error.

Backpropagation is one of the most important ANN paradigms since it is reasonably simple to implement and works extremely well for a wide variety of applications. Backpropagation is used to calculate the gradient of the error of ANN with respect to its modifiable weights. Therefore the backpropagation method is an iterative gradient algorithm designed to minimize the error between the generated output and the actual output of a multilayer feedforward 'perceptron' (Goh, 2000).

A backpropagation based ANN consists of an input layer, one or more hidden layers and an output layer. By using the gradient steepest descent method, training cases are entered into the network to get the weights and biases between the input and hidden layers and those between the hidden and output layers (Hsiao and Huang, 2002). The output of each neuron is modified by the sigmoid transfer function, which express the output of each hidden neuron (in the form given in Equation 5.1) and that of each output neuron (in the form given in Equation 5.2):

$$f(x_j) = 1/(1+\exp(-(\sum_{i=1}^{n} X_i \cdot W_{ij} - \theta_j))), \quad (5.1)$$

$$f(x_k) = 1/(1+\exp(-(\sum_{j=1}^{m} X_j \cdot W_{jk} - \theta_k))), \quad (5.2)$$

where, Xi is the value of the input variable, Wij and Wjk are connection weights between the input and the hidden neuron and between the hidden neuron and the output neuron, respectively, θij and θjk are bias terms for the *ith* and *kth* neuron, respectively; *i, j,* and *k* are the number of neurons in each layer (Kim et al., 2004). Two important issues in determining the structure of an ANN model are the selection of the network architecture and the learning algorithm.

5.3.3 Data for ANN

Once ANN is found to be a useful method to develop a decision support model, data need to be gathered to train the network. The data set used for the training includes a number of cases and each case has a range of input and output variables. The researcher should decide how many cases to gather and which variables to use from the collected data set. Numeric data can be scaled into an appropriate range for ANN, and missing values can be substituted to use as the mean value (Bishop, 1995). It is difficult to deal with non-numeric data such as nominal variables. Even though ANN does not perform very well with nominal variables having a large number of possible values, it is still possible to use nominal variables coded in numbers.

One thing that frequently presents difficulties is the number of cases needed for ANN modeling. The required number of cases for most practical problem domains will be in the hundreds (Hill and Lewicki, 2007). However, in developing business classification models, a small data set is a common problem. The author has found literature support for running ANN with relatively small data samples (N<100) to train

the network (Fletcher and Goss, 1993; Walezak et. al., 2002; Radonja and Stankovic, 2002; Ling and Liu, 2004). For instance, Walezak et. al. (2002) used 61 loan cases to train and 15 cases to test, and Ling and Liu(2004) used 33 design build project cases to ascertain the predictor variables of 11 performance metrics(outputs), and only five new projects cases were used to test their ANN model.

5.4 ANN-based Decision Support Model Development

5.4.1 Reasons for Selecting ANN

One of the two main objectives of this research is to develop an AWA decision support model that allows decision makers to predict an appropriate AWA type along with the expected satisfaction level. The artificial neural network (ANN) modeling technique is selected to develop the decision model for the following reasons:

First, ANN is a good example of the "black box" approach, which yields accurate prediction results but can not identify the specific relationships on which the predictions are based. The main purpose for developing a decision model is to be able to predict the output more accurately rather than to identify the specific relations between the variables.

Second, the data collected for this research are mixed forms of nominal and ordinal data. The output variables of the data are nominal with six levels (Y1) and ordinal with three levels (Y2). Given the nature of the output variables, ANN performs well since it is less sensitive to the categorical nature of data.

Third, ANN has the major attractive property of generalization, which is the ability to use information that ANN has gathered during the learning period to synthesize input-output mapping with new data.

The final reason for selecting ANN is that it is also possible to run ANN to predict outcomes of both AWA type selection, denoted as Y1, and satisfaction level, denoted as Y2, simultaneously.

5.4.2 ANN Software

Two important issues in determining the structure of the ANN model are the selection of the network architecture and the learning algorithm. According to the literature review on ANN modeling, the structure of ANN model was determined: Feedforward architecture with a backpropagation learning algorithm.

The ANN software chosen for this research is EasyNN-plus by Neural Planner software Ltd. EasyNN-plus was selected because of its ease of use, cost, accurate prediction ability using variables provided in the learning stage, and its provision of detailed information such as diagrams, graphs and the input/output data displayed. The network architecture of EasyNN-plus is feedforward, and its learning algorithm is backpropagation. It is different from most other backpropagation in its based applications, which are the data structures, and the way the data are presented to the learning algorithm. EasyNN-plus uses double linked lists to store the examples, the nodes and the connections. The lists can be processed quickly in both directions simultaneously. The lists can also be extended and contracted dynamically.

5.4.3 Data Coding and Selection of Variables

The seven objectives of AWA adoption denoted as A1-A7 were binary-coded (“0”=not selected or “1”=selected) since the importance among three objectives selected by respondents was not ranked. The readiness levels measured by the 18 different indicators are denoted as X1-X18, and they were coded into three levels(“1”=relatively low, “2”=medium or “3=relatively high). Different AWA types, denoted as Y1, were coded into six levels (“1”=hoteling, “2” group address, “3”=shared office, “4”=satellite

office, “5”=home office and “6”=virtual office). Finally, the satisfaction levels, denoted as Y2, were coded into three levels (‘1”=less satisfied, “2”=satisfied, and “3”=highly satisfied).

As discussed in Chapter 4, among the 18 variables measuring the readiness level of each case, 16 variables are positively correlated with the satisfaction level of AWA adoption, and among the 16 readiness variables showing a positive rank correlation with Y2, 13 variables are significant at the .01 level (99% level) for a two-tailed prediction. Therefore, it was decided to use all of the X variables to develop the ANN decision model because 89 % of all the predictor variables show a positive rank correlation with Y2. It was decided to use all of the AWA objective variables denoted as A1-A7 and the AWA type variables denoted as Y1 were to develop the ANN model since ANN is less sensitive to the categorical nature of data.

5.4.4 ANN Operation

In order to validate that the assessment items in the RLAI are indeed key determinants affecting decisions regarding the AWA type selection and anticipated satisfaction level, the ANN method is adopted to check its reasonable prediction ability. The ANN method is selected because it has a robust learning capability and fairly accurate prediction ability, even if the information is incomplete, especially for the decision content of this research, which is the complex nonlinear relationships between inputs and outputs (Ling and Liu, 2004). Because the network architecture of EasyNN-plus is feedforward and its learning algorithm is backpropagation, EasyNN-plus was used to train and test the predictive performance of the ANN model for the AWA type selection and satisfaction level.

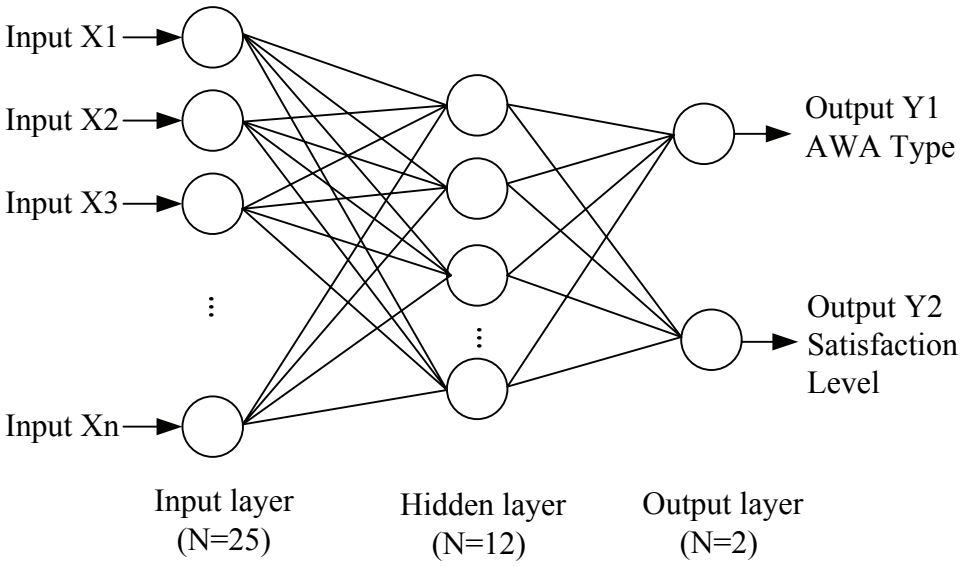
One of the main difficulties found in developing the ANN model is the problem of overtrainning or overfitting. The size of the networks needs to be minimized to prevent ANN from over-fitting the data, and each architecture has it’s quantity of hidden nodes

incremented by two until prediction performance starts to decline, indicating over-fitting of the data(Walczak & Cerpa, 1999).

The common procedures to avoid overtraining include adding prior knowledge to the model. There are two ways to add prior knowledge to the network (Radonja and Stankovic, 2002).

- Reduce the size of the ANN model by decreasing the number of neurons in the hidden layer(s)

- Stop the training process early. Stopping the training process manually sometimes increases the errors.



N: Number of Neurons

Figure 5.3 ANN Architecture

In order to prevent ANN from overtraining, ANN was started with only eight neurons in the hidden layer and was optimized with 12 neurons in the hidden layer. There should be at least three layers required for the backpropagation learning algorithm. Therefore, for the network architecture in this research, as shown in Figure 5.3, the number of neurons in the input, hidden, and output layer are 25, 12, and 2, respectively.

After the specific ANN architecture was designed, in the first phase, 52 of the 64 high-tech companies were randomly selected to be used as inputs. ANN was then trained with the 52 real adoption cases. The learning process started when the input values along with desired output values were entered into the ANN input layer. ANN propagated the input pattern from one layer to the next layer until the output pattern was determined. When the output pattern was different from the desired output pattern, the error was calculated. The error was then propagated backwards, and the connection weights of each of the neurons were modified.

The target error can be changed to any value from 0 to 0.9 in EasyNN-plus; however, values above 0.2 usually result in an under trained ANN. Thus, the target training error was set to 0.01, which meant that each record was to be within 0.01 of the actual value. The training was stopped when the average training error dropped below the target error (0.008). Therefore, all cases were successfully trained. The sum of the squared errors is usually considered a stopping criterion for the training process (Stalinski and Tuluca, 2006). The sum of the squared error can be calculated using the Equation in 5.3.

$$E_n = \frac{1}{2}\sum_{k=1}^{k} (P_k - A_k)^2 \qquad (5.3)$$

where P_k is the activation of output unit k and A_k is corresponding target for inputs.

In the second phase, after the training was stopped, a reserved data set consisting of 12 cases, called a testing or validating set, was entered into the ANN. The completed network with 25 neurons in the input layer are denoted as yellow, the 12 neurons in the hidden layer are denoted as blue, and the 2 neurons in the output layer are denoted as pink as shown in Figure 5.4. The network view shows how the neurons in the ANN are interconnected.

In the last phase, the performance of the ANN was evaluated by comparing the predicted values of the ANN and the actual values in the testing set. One measure is the ability of the ANN to correctly classify the AWA type selected by high-tech companies. The other measure is the ability of the ANN to correctly classify the satisfaction level reported by the high-tech companies.

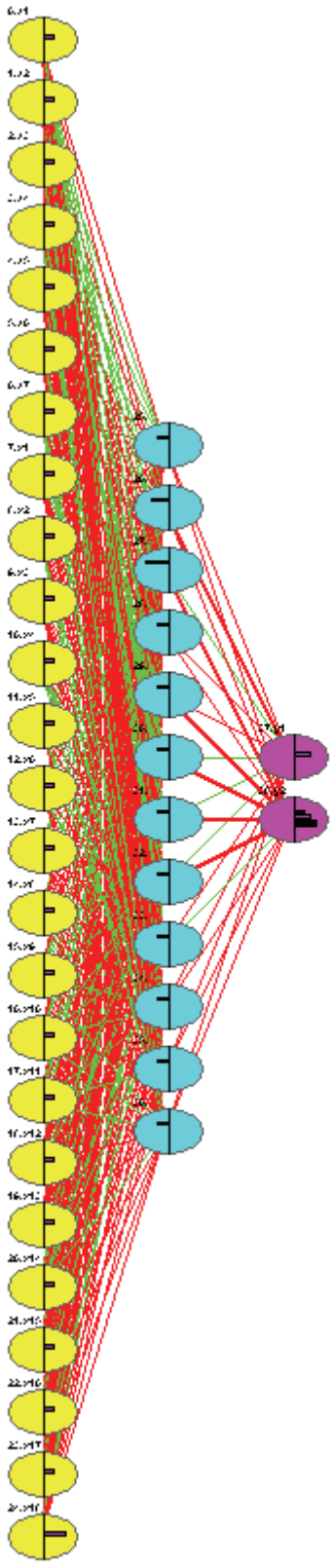


Figure 5.4 The Completed Neural Network

5.5 Results

5.5.1 Input Importance

EasyNN-plus offers an input importance view, revealing the importance of each input column as shown in Figure 5.5. The importance is the sum of the absolute weights of the connections from the input neurons to all the neurons in the first hidden layer. The inputs are shown in descending order of importance from the most important input to the least important input.

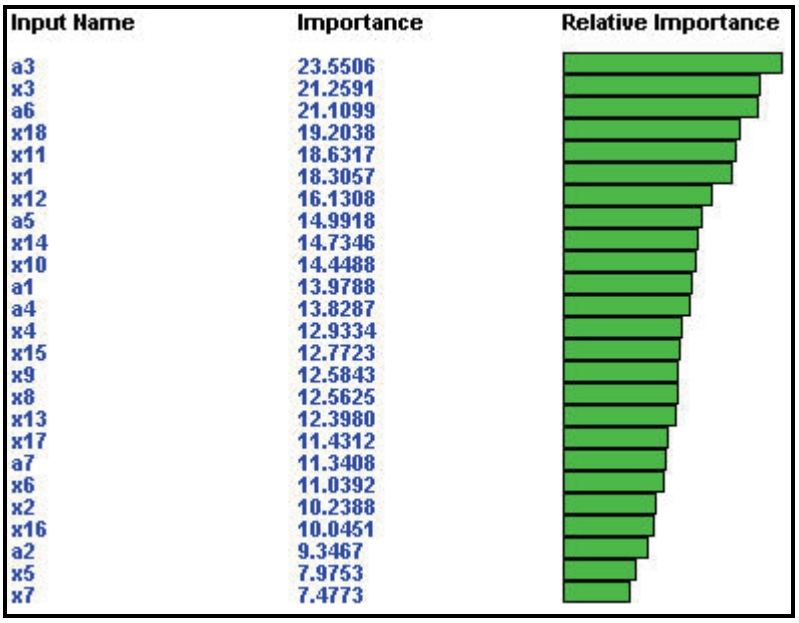


Figure 5.5 Importance of Input Variables in the Descending Order

Figure 5.5 shows that among objective variables and readiness variables used as the input variables, A3, which is improved productivity, is the most important input variable by the sum of weights in ANN model. Among the readiness variables, X3, which is the level of trust between managers and their employees, is the most important variable in the ANN model. According to the result of ANN operation, the following are the top ten important input variables in terms of the sum of the weights of connections in ANN.

1. A3: Improved productivity

2. X3: The level of trust between managers and their employees

3. A6: Reduced traffic congestion and environmental impacts

4. X18: X18: Clear policy/guideline provision for AWA

5. X11: Employees' level of familiarity with ICT

6. X1: The level of AWA supported at all levels of the organization

7. X12: Employees' work experiences with flexible work style

8. A5: Improved customer satisfaction

9. X14: The level of premises support services

10: X10: Employees' level of self-sufficiency to work

In addition to Xs, readiness variables, the As, AWA objective variables are also important in linking to the hidden layer in ANN and their importance is shown in Figure 5.6 by variable numbers.

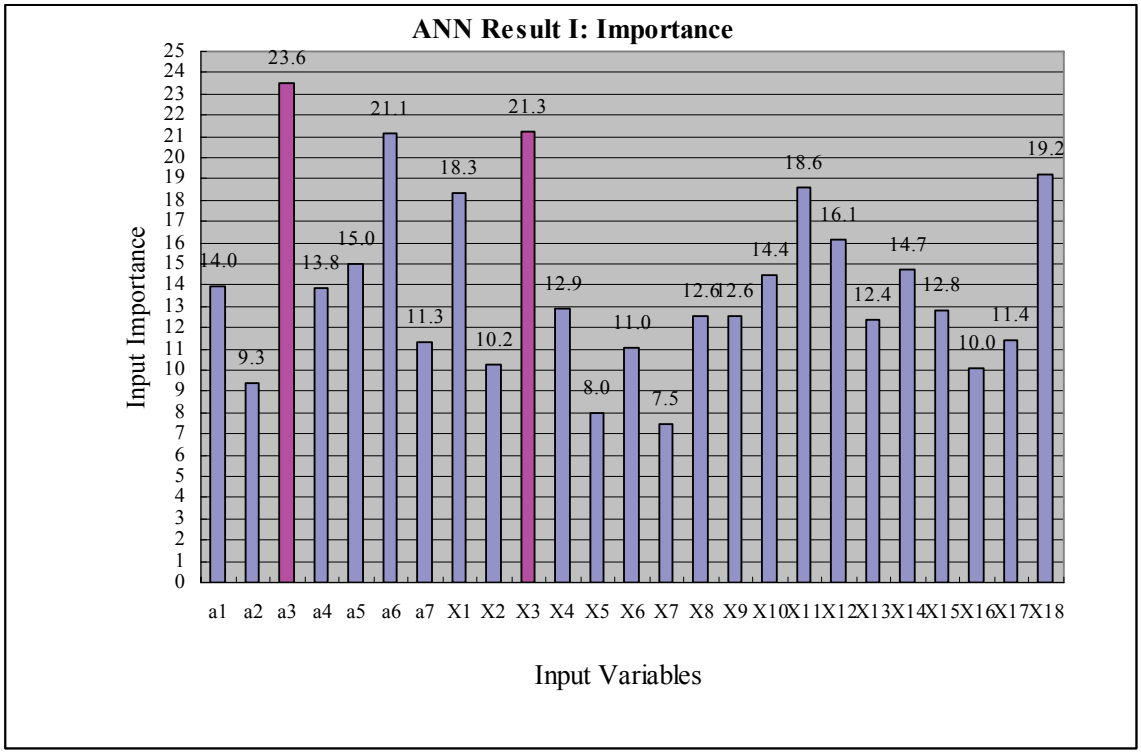


Figure 5.6 Result I: Importance of Input Variables by Variables Numbers

5.5.2 Sensitivity

EasyNN-plus uses the term "sensitivity" to show how much an output changes when the inputs are changed. The inputs are all set to the median values, and then each, in turn, is increased from the lowest value to the highest value. The change in the output is measured as each input is increased from lowest to highest to establish the sensitivity to change. The inputs are shown in descending order of sensitivity from the most sensitive input to the least sensitive input as shown in Figure 5.7.

Input Name	Change from	to	Sensitivity	Relative Sensitivity
a3	0	1	0.025857536	
x4	1	3	0.019972011	
a1	0	1	0.006029919	
x14	1	3	0.005214127	
a6	0	1	0.004441078	
x18	1	3	0.004199387	
a5	0	1	0.003614597	
x3	1	3	0.002768143	
x1	1	3	0.002115647	
a7	0	1	0.001907241	
x11	1	3	0.001828740	
x6	1	3	0.001748640	
x2	1	3	0.001563293	
a4	0	1	0.001287137	
x10	1	3	0.000859510	
x15	1	3	0.000835014	
x17	1	3	0.000820157	
x7	1	3	0.000713398	
x12	1	3	0.000566293	
x8	1	3	0.000539154	
x13	1	3	0.000509231	
x9	1	3	0.000486387	
a2	0	1	0.000471595	
x5	1	3	0.000273185	
x16	1	3	0.000167504	

Figure 5.7 Sensitivity of Input Variables in Descending Order

Among objective variables and readiness variables used as the input variables, A3, improved productivity, is the most sensitive input variable in the ANN model. Among readiness variables, X4, the level of interaction and communication needed to perform the work, is the most sensitive input variable in the ANN model. According to the results of ANN operation, the following are the top ten sensitive input variables as shown in Figure 5.8 by variable numbers.

1. A3: Improved productivity

2. X4: The level of interaction and communication needed to perform the work

3. A1: Retention/attraction of skilled employees

4. X14: The level of premises support services

5. A6: Reduced traffic congestion and environmental impacts

6. X18: Clear policy and guideline provision for AWA

7. A5: Improved customer satisfaction

8. X3: The level of trust between managers and their employees

9. X1: The level of AWA supported at all levels of the organization

10. A7: Employment opportunities for aging and handicapped people and employees' work-life balance

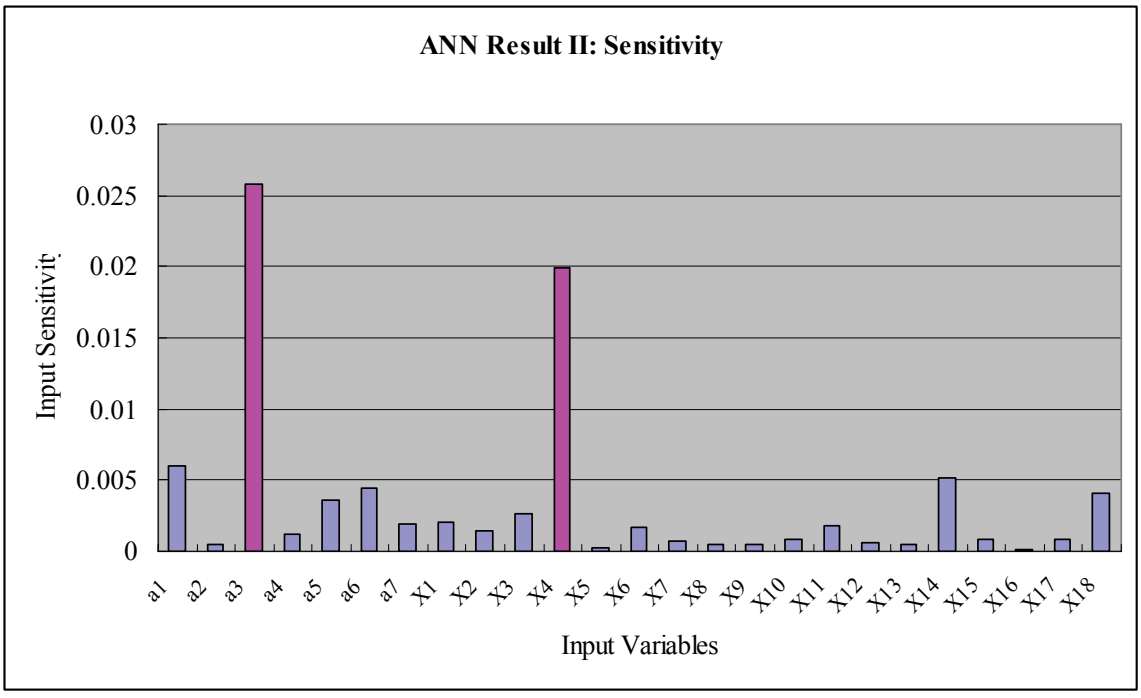


Figure 5.8 Result II: Sensitivity of Input Variables by Variable Numbers

5.5.3 Predictive Performance

The testing data set consisting of 12 cases was used to evaluate the ANN model's predictive performance. Its performance was validated by comparing the predicted values of ANN for AWA type selection with six levels, denoted as Y1, and satisfaction with three levels, denoted as Y2, and the actual corresponding values in the testing set. First, the predictive performance of the ANN was evaluated to see how accurately it could classify the AWA type selected by the high-tech companies. The other measure was its ability to correctly predict the satisfaction level reported by the participating high-tech companies.

Table 5.1 ANN Model Predictions

Testing Cases	**Actual values**		**ANN predictions**	
	Type Selection(Y1)	Satisfaction Level (Y2)	Type Selection(Y1)	Satisfaction Level (Y2)
C6	Hoteling	Level 1	Hoteling	Level 1
C7	Hoteling	Level 3	Hoteling	Level 3
C14	Group Address	Level 3	Group Address	Level 3
C16	Group Address	Level 3	Group Address	Level 3
C20	Shared Office	Level 3	Satellite Office	Level 2
C24	Shared Office	Level 3	Hoteling	Level 3
C33	Satellite Office	Level 3	Satellite Office	Level 3
C36	Satellite Office	Level 3	Satellite Office	Level 3
C43	Home Office	Level 3	Home Office	Level 3
C46	Home Office	Level 3	Home Office	Level 3
C61	Virtual Office	Level 3	Virtual Office	Level 3
C64	Virtual Office	Level 2	Virtual Office	Level 2

The result of the ANN model, as shown in Table 5.1, illustrates that there are relatively reliable predictions with only slight differences between the ANN predictions and the actual values of the testing data set.

5.5.4 Prediction Error

In order to measure the amount of error, the relative measure of accuracy was used to validate the predictions of the ANN model using the Equation 5.4.

$$PE = \sum_{i=1}^{M} (\sqrt{(AV_i - PV_i)^2 / \max(AV_i, PV_i]}) / N \qquad (5.4)$$

where PE is the percentage error of cases; AV and PV represent actual value and predicted value for m cases, respectively.

Table 5.2 Percentage Error (PE) and Prediction Accuracy of the ANN Model

Testing Cases	**ANN predictions**	
	Type Selection (Y1)	Satisfaction Level (Y2)
C6	0.00%	0.00%
C7	0.00%	0.00%
C14	0.00%	0.00%
C16	0.00%	0.00%
C20	25.00%	33.33%
C24	66.67%	0.00%
C33	0.00%	0.00%
C36	0.00%	0.00%
C43	0.00%	0.00%
C46	0.00%	0.00%
C61	0.00%	0.00%
C64	0.00%	0.00%
Average PE	7.64%	2.78%
Prediction Accuracy	83.33%	91.67%

Table 5.2 displays the percentage error and prediction accuracy of the ANN model in the testing set. The overall prediction accuracy of the ANN in the training set is 100%, indicating that the ANN model perfectly learned the training set of the high-tech

companies. In the testing set, the overall prediction accuracy is slightly lower: the ANN was able to correctly classify 10 out of the 12 AWA type selections, yielding 83.3% accuracy, and it was also able to correctly classify 11 out of the 12 satisfaction levels, yielding 91.67% accuracy. The average percentage error is 7.64% for type selection and 2.78% for satisfaction level.

5.6 Model Validation

As the first model validation step, performance prediction of the ANN model is commonly evaluated by comparing the actual and the desired outputs in the testing sets and it was done in the previous section. When the trained ANN shows good prediction accuracy for the testing data that the ANN has never seen before, it can be concluded that the ANN is validated.

For its second model validation step, this research also adopts case-based reasoning (CBR) to compare the prediction accuracy of the ANN with that of CBR. CBR is a problem solving technique in which past cases and experiences are re-used to find a solution to particular problems. CBR technique is similar to the expert judgments that usually depend on the use of experience to solve business problems (Kim et. al., 2004). It is a method to capture a new experience and make it immediately available for problem solving. CBR can be considered a learning and knowledge-discovery approach because it can capture some general knowledge from a new experience (Shin and Han, 2001).

Some research has also proved that CBR can be an effective prediction method for complicated problems (Wang et al., 2008). By calculating the percentage similarity based on the nearest neighbor approach, CBR can indicate the similarity between stored cases and newly input cases, as shown in Equation 5.5. That is, every attribute in the input case is matched to its corresponding attribute in the stored case, and the decision maker can easily acquire the prediction result from information of these stored cases.

$$Similarity(T,S) = \sum_{i=1}^{F} (W_i \cdot [1 - \sqrt{(T_i - S_i)^2 / \max(T_i, S_i}]) \qquad (5.5)$$

where W_i is the weight of feature i, T is the target case, S is the source case. F is the number of attributes in each case, and i is an individual feature from 1 to F.

The training set consisting of 52 cases was stored in the case base, and these data were used to calculate the percentage similarity and to retrieve a similar case based on the percentage similarity. As shown in Table 5.3, the stored cases column indicates cases selected from the stored cases (training cases) based on the highest percentage similarity among all 52 cases.

Table 5.3 CBR Model Results

Target cases	Stored Cases	Percentage Similarity	CBR predictions Error	
			Y1	Y2
C6	C4	82.00%	Correct	Incorrect
C7	C27	91.33%	Incorrect	Incorrect
C14	C18	96.00%	Correct	Correct
C16	C13	98.00%	Correct	Correct
C20	C22	82.67%	Correct	Incorrect
C24	C49	90.67%	Incorrect	Correct
C33	C32	86.67%	Correct	Correct
C36	C41	83.33%	Correct	Incorrect
C43	C44	92.00%	Correct	Correct
C46	C45	93.33%	Correct	Incorrect
C61	C60	98.67%	Correct	Correct
C64	C63	96.67%	Correct	Correct
Average		90.95%	83.33%	58.33%

Table 5.3 also shows that the CBR model was able to correctly classify 10 out of the 12 AWA type selections, yielding 83.3% accuracy. This prediction accuracy of CBR model regarding type selections (Y1) is the same as that of the ANN model. The CBR model was also able to correctly classify 5 out of the 12 satisfaction levels, yielding 58.33% accuracy, which is much lower than that of the ANN model.

Table 5.4 Error Rate Comparison between the ANN and CBR Model

Testing Cases	**ANN predictions**		**CBR predictions**	
	Type Selection(Y1)	Satisfaction Level (Y2)	Type Selection(Y1)	Satisfaction Level (Y2)
C6	0.00%	0.00%	0.00%	50.00%
C7	0.00%	0.00%	66.67%	33.33%
C14	0.00%	0.00%	0.00%	0.00%
C16	0.00%	0.00%	0.00%	0.00%
C20	25.00%	33.33%	0.00%	33.33%
C24	66.67%	0.00%	40.00%	0.00%
C33	0.00%	0.00%	0.00%	0.00%
C36	0.00%	0.00%	0.00%	33.33%
C43	0.00%	0.00%	0.00%	0.00%
C46	0.00%	0.00%	0.00%	33.33%
C61	0.00%	0.00%	0.00%	0.00%
C64	0.00%	0.00%	0.00%	0.00%
Average PE	**7.64%**	**2.78%**	**8.89%**	**15.28%**
Prediction Accuracy	**83.33%**	**91.67%**	**83.33%**	**58.33%**

Table 5.4 compares the prediction accuracy in percentage error of the ANN model and the CBR model. The average percentage errors of the ANN model for predicting Y1 and Y2 are 7.64% and 2.78% respectively, whereas the average percentage errors of the CBR model for predicting Y1 and Y2 are 8.89% and 15.28% respectively. Additionally, the prediction accuracy of the ANN models for Y2 indicates 91.67%, whereas one of the CBR models for Y2 shows 58.33%.

Therefore, it is validated that the ANN model is more effective and robust in predictive performance than the CBR model.

5.7 Decision Support Process

This dissertation resulted in the development of the decision support process. The first question in this decision support process is whether facility managers can clearly identify the relative advantages of adoption supporting the overall goals and objectives of the organization, and, given its identified advantages and current readiness conditions, what the most suggested AWA type and anticipated satisfaction level are. Expanding on prior research, this dissertation provides facility managers with RLAI to assess the readiness of an organization to adopt AWA. According to the results of the readiness assessment, the ANN-based decision model additionally suggests an AWA type and the anticipated satisfaction level. As depicted in Figure 5.9, a suggested decision process is developed to assist facility managers in assessing the readiness and obtaining decision support. Six steps, as shown in Figure 5.9 are established in this process:

Step 1: AWA consideration

Consideration of the AWA adoption starts by gathering information on relative advantages.

Step 2: Identification of clear relative advantages

If the decision makers can not clearly identify the expected benefits from adopting AWA, then their organizations are not ready for AWA yet. In this case, the decision maker should identify clear objectives of adopting AWA to continue to use this system.

Step 3: AWA readiness assessment

According to a three -point liker scale ("1"= relatively low, "2"=medium, "3"=relatively high), the decision makers are requested to rate their organizations' existing readiness condition. Based on the inputs in RLAI, the participating organization's readiness levels are assessed along with the three important objectives of AWA adoption identified in step 1.

Step 4: ANN operation process

Out of the 64 AWA adoption cases collected, 80% of data is used for training the ANN model, and the remaining 20% of data is reserved for testing the ANN model. Therefore, 52 cases were stored in the ANN, and 12 cases were reserved for testing. The ANN operation process includes ANN setup, training and testing cases from the database. The ANN operation process is described more in a later section.

Step 5: ANN output

The performance of the ANN model is commonly evaluated by comparing the actual and the desired outputs in the testing sets. The initial outputs from operating an ANN-based

decision model demonstrate the prediction results, including suggestions for AWA types along with the anticipated satisfaction level.

Step 6: ANN model validation

As the first validation step, the actual outputs and the predicted outputs were compared in step 5. As the second validation step, in order to test the ANN-based model's potential in dealing with the decision context of this research, the case-based reasoning (CBR) method is adopted for the model validation. Case-based reasoning (CBR) is a problem solving technique in which past cases and experiences are re-used to find a solution to particular problems (Shin and Han, 2001). Some research has proved that CBR is an effective prediction method for complicated decision problems (Wang et al., 2008). By calculating the percentage similarity based on the nearest neighbor approach, CBR can indicate the similarity between stored cases and newly input cases, as shown in Equation 5.3. To implement the concept, the nearest neighbor search (NNS) is a simple and straightforward method to assess the similarity between stored cases in ANN and the newly input cases. Every variable in the training data set is matched to its corresponding variable in the testing data set, and the degree of match of each pair is then computed using the matching function.

$$Similarity(T,S) = \sum_{i=1}^{F} (W_i \cdot [1 - \sqrt{(T_i - S_i)^2 / \max(T_i, S_i}]) \qquad (5.5)$$

where, T is the stored case(training data), S is the newly input case(testing data), and F is the number of variables

Possible actions to take

There could be three possible actions that facility managers take for the success of AWA so as to be more competitive in business.

- The first action is adjustment in the appropriateness level and overcoming level by transformation and innovation when the situation of the organization is not yet appropriate for the targeting AWA type given the objectives.

- The second action is that the organization can advance to the AWA type most aligned given the organization's readiness level even if the type is not matched to their initially prioritized benefits.

- The final action is the combined form of two actions above. For instance, while adjusting each level, the organization can change the AWA type to the most achievable one.

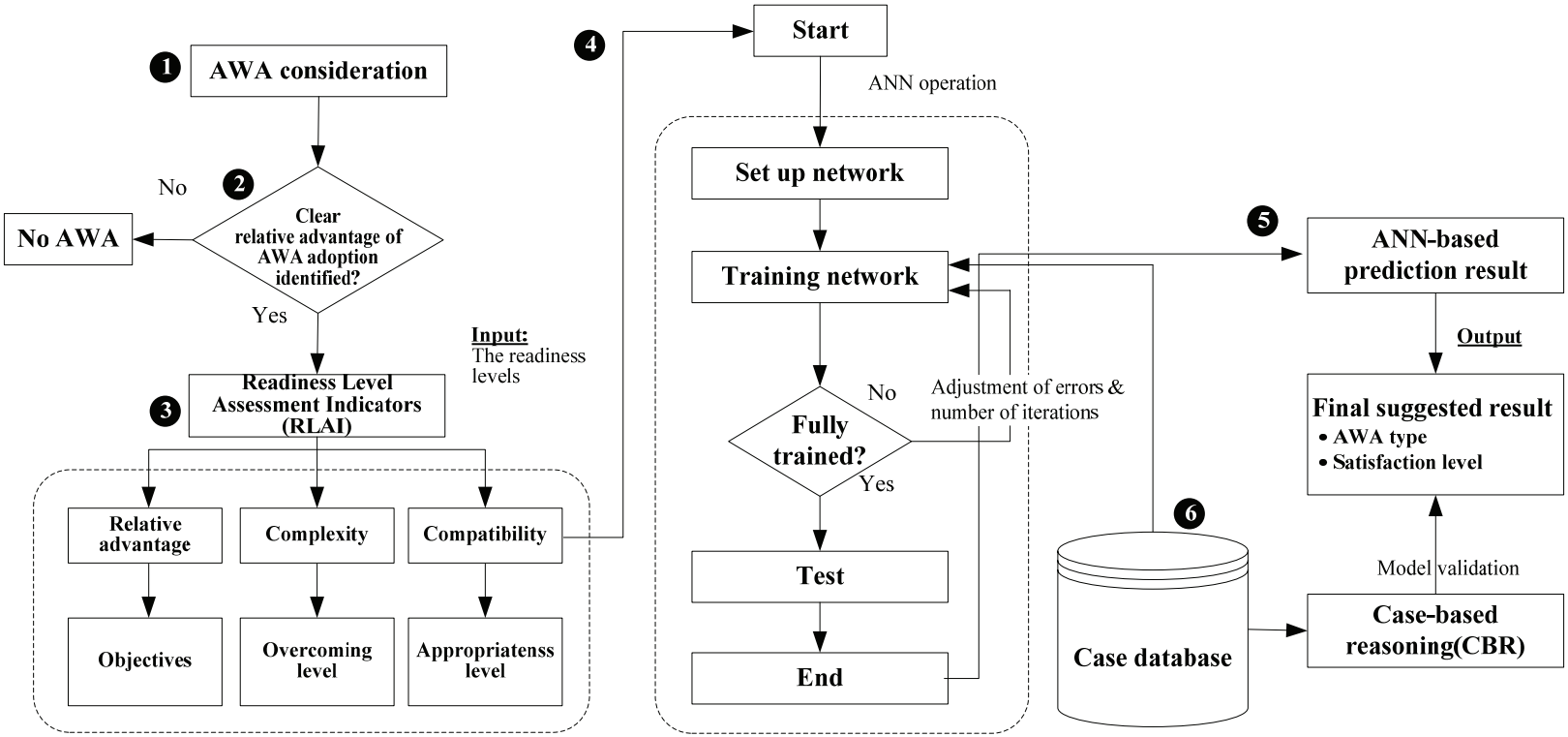


Figure 5.9 ANN-based Decision Support Process

CHAPTER 6

SUMMARY AND CONCLUSIONS

6.1 Overview

Facility management (FM) has emerged and evolved over the past few decades to better prepare organizations for rapid changes in business, influences of ICT, and the dramatic shifts in requirements for workers focused on knowledge rather than production. Today, facilities are beginning to be recognized as strategic business resources, and facility managers are becoming recognized as the asset managers commonly responsible for supporting the entire organization.

Facility managers have the potential to promote and enhance the AWA environment and are responsible not only for the central office physical facilities but also for AWA, however, currently, facility managers have limited tools to assess their organizations' readiness for the adoption of AWA or to select among the possible choices on which AWA type if more appropriate considering their organizations' business reasons of adoption and current readiness conditions.

The goal of this dissertation is to provide an understanding of the assessment of the initial readiness for AWA adoption and to develop a decision support model which can predict an appropriate AWA type and satisfaction level to assist the process of decision-making for AWA adoption from an organizational perspective.

The specific objectives are as follows:

1) To develop a set of readiness level assessment indicators (RLAI) for assessing the extent of an organization's readiness for the adoption of AWA. As for the first contribution of this research, RLAI is developed and facility managers can utilize RLAI

as important indicators which can help them effectively measure the potential readiness of AWA adoption.

2) To develop an AWA decision model, based on actual AWA adoption cases from high-tech companies. As for the second contribution of this research, ANN-based decision support model is developed and facility managers can predict an appropriate AWA type along with the expected satisfaction level using the decision support model.

This chapter summarizes the research process, research outcomes, conclusions that are drawn from data analysis and ANN modeling. Finally, recommendations for future research are provided.

6.2 Research Process

This research consists of six chapters. Chapter 1 provides an overview and background study, a problem statement from which the objectives of this research are formed, and the scope, assumptions and methodologies of this research. Chapter 2 provides an extensive review of the literature on a wide range of AWA issues and summarizes major business reasons, significant factors and relevant attributes of AWA adoption. In Chapter 3, the findings from the extensive review of the literature and an evaluation from an expert panel are combined to finalize the assessment indicators for developing an RLAI. Using the RLAI, real AWA adoption cases from high-tech companies are collected and analyzed to test the hypothesis of this research in Chapter 4. An artificial neural network (ANN) based decision support model is developed and validated by a case-based reasoning (CBR) model in Chapter 5. It was validated that the ANN model is more effective and robust in predictive performance than the CBR model is.

6.3 Research Outcomes

The first outcome of this research is the RLAI. First, a tentative RLAI is developed based on combined insights from the literature review and discussions at the 2008 International Facility Management Association (IFMA) Atlanta Workplace. Next, selected assessment indicators are additionally evaluated for their validity by the panel of experts formed for this research in order to finalize the RLAI, which measures the initial readiness of high-tech companies to adopt an AWA.

The second outcome of this research is the ANN-based decision model, which predicts an appropriate AWA type and the expected satisfaction level simultaneously. Predictive data mining techniques are reviewed since the main goal of predictive data mining is to identify a statistical or artificial neural network (ANN) model that can be used to predict outcomes in business.

The regression technique is abandoned for developing a decision model because it is not very useful for small data samples and it performs better for the output variables containing continuous data. Additionally, two outputs, type selection (Y1) and satisfaction level (Y2) can not be investigated at the same time using the regression technique.

The ANN technique is selected to develop a decision model for the following reasons. First, the main purpose of developing a decision model is to predict the outputs as accurately as possible rather than to identify the specific relations between the variables. The ANN is a good example of a "black box" approach, one which yields accurate prediction results. Next, the output variables of the data are nominal with six levels (Y1) and ordinal with three levels (Y2). The literature suggests that the ANN performs very well when the output variables contain categorical values (Miles and Shevlin, 2001). Finally, it is also possible to run the ANN to predict outcomes of both

AWA type selection, denoted as Y1, and satisfaction level, denoted as Y2, simultaneously.

The ANN-based decision model reliably suggests an AWA type and anticipated satisfaction level given the objectives and the readiness level of high-tech companies. As the first ANN model validation, predictive performance of the ANN model is evaluated by comparing the actual and the desired outputs in the testing sets. Additionally, as the second validation, this research also adopts a case-based reasoning (CBR) technique to develop the second decision model. Predictive performances of the two decision models are compared in Chapter 5. Consequently, it is validated that the ANN model is more effective and robust in predictive performance than the CBR model is. Additionally, a decision support process is suggested to assist facility managers in assessing the readiness and obtaining decision support in Chapter 5.

6.4 Conclusions

This research resulted in the development of readiness level assessment indicators (RLAI), which measure the initial readiness of high-tech companies to adopt an AWA. It also built an ANN based decision model, which allows facility managers to predict an appropriate AWA type and anticipated satisfaction level considering their organization's objectives and the current readiness level.

This research has identified significant factors and relative attributes for facility managers to consider when measuring their organization's readiness for AWA adoption.

Based on the analysis of the data and the ANN decision support model, the following have been concluded:

(1) Among 18 variables used to measure the readiness level of each case, the following 16 variables are positively correlated with the organization's level of satisfaction with AWA adoption.

X1: The level of AWA supported at all levels of the organization

X2: The degree of equal promotional opportunity for distributed workers

X3: The level of trust between managers and their employees

X5: The degree of sequential work process vs reciprocal process

X6: The degree of autonomy for work

X7: The level of clarity of defined deliverables

X9: Employees' level of preference for AWA

X10: Employees' level of self-sufficiency to work

X11: Employees' level of familiarity with ICT

X12: Employees' work experiences with flexible work style

X13: The provision of ICT support

X14: The level of premises support services

X15: The level of business support services

X16: Result-based performance evaluation method in practice

X17: Virtual teamwork in practice within the organization

X18: Clear policy/guideline provision for AWA

Of special note, X1, X3, X7, X12, X13, X15 and X18 are highly correlated with the satisfaction level expressed in how much an adoption meets the initial objective of the AWA adoption(correlation is significant at the .01 level). Therefore, it is concluded that the hypothesis of this research is confirmed:

H: A positive rank correlation exists between organizational readiness level for AWA adoption and organization's satisfaction with AWA.

(2) Three important features are revealed from analyzing only 33 best practice cases.

First, more important objectives are found in each of six AWA type adopted by participating high-tech companies. These findings are meaningful to appreciate as the objectives for adopting AWA can impact the implementation and future success of the adoption.

The most important objectives selected in the best practice type, hoteling, are "reduced office space costs" and "improved productivity". For the second on-site type, group address, "improved productivity" and "reduced turnover and absenteeism" are two major objectives whereas "reduced office space costs" and "employee's work-life balance" are found to be more important objectives in adopting shared office type.

Best practice cases revealed that more companies adopted the first off-site type, satellite office in order to improve productivity and customer satisfaction. The second and third off-site types, home office and virtual office were selected for reducing office space costs and for improving customer satisfaction. This indicates that participating high-tech companies successfully adopting AWA had similar objectives in adopting home office and virtual office.

Another finding is that the average overcoming levels of off-site types are higher than those of on-site types in three measurement areas such as "results-based on performance evaluation method in practice", "virtual team work in practice within the organization" and "clearly written policy, guideline and procedure provision for AWA".

The final feature is that among the 15 appropriateness measurements, the average appropriateness levels of off-site types indicate higher incidence than the ones of on-site types in 11 areas. However, appropriateness levels for on-site types are higher in the four features of "the level of interaction/communication needed to perform the work", "the degree of sequential work process vs. reciprocal process (The degree of transactional vs. open ended work process)", "required physical presence at the office for work to be able

to access specific technology, equipment or live interpersonal response" and "the level of premise supports including building operation and maintenance and cleaning.

(3) Among the objective variables denoted as A1-A7, the following variables are relatively more important in predicting an appropriate AWA type and anticipated satisfaction level. The input importance is determined based on the sum of the absolute weights of the connections from the input neurons to all the neurons in the ANN model:

A3: Improved productivity

A5: Improved customer satisfaction

A6: Reduced traffic congestion and environmental impacts

(4) Among the objective variables and the readiness variables used as the inputs for the ANN modeling, when the following variables change, the output variables change greatly.

Therefore, the following variables are more sensitive than the other variables:

A3: Improved productivity

X4: The level of interaction and communication needed to perform the work

A1: Retention/attraction of skilled employees

X14: The level of premises support services

A6: Reduced traffic congestion and environmental impacts

(5) Finally, the ANN-based decision support model is developed and validated. Robust predictive performance of the ANN model shows that the main factors or key determinants have been correctly identified in RLAI and can be used to predict an

appropriate AWA type and anticipated satisfaction level of AWA adoption for high-tech companies.

6.5 Future Research

This research provides facilities managers with increased understanding in assessing the current readiness levels and suggestions regarding AWA type selection along with anticipated satisfaction level. A set of readiness level assessment indicators (RLAI) with three main categories of relative advantage, compatibility and complexity is developed to help facility managers assess their organizational readiness for AWA adoption. Based on a total of 64 real AWA adoption cases collected from high-tech companies, an ANN-based decision support model is developed.

The scope of this research is limited to only the initiation stage and adoption stage. In the future, it will be necessary to extend the scope to the next implementation stage, where a detailed feasibility study including cost estimation and risk analysis for the final adoption decision is conducted.

With 64 adoption cases, the ANN-based decision model shows more accurate prediction on actual values than a CBR-based model does. In future research, based upon a larger sample of AWA adoption cases from other industries, more efforts could be researched to develop decision support systems which can provide even more accurate and solid predictions regarding AWA adoption decision issues as well as measure the performance of distributed workers.

APPENDIX A:
KEY TERMS OF AWA AND THEIR DEFINITIONS

1. **Alternative Workplace Arrangements (AWA)**: A decentralized organizational structure where the core organization distributes a portion of its functions to a remote site(s). AWA also includes various types of alternative working rather than traditional working at assigned workstations in the primary office. The definition of AWA for this dissertation is the workplace arrangements enabled by ICT that allow employees to work on or off-site.

2. **Information and Communication Technologies (ICT)**: Advanced telecommunications technologies used for the rapid transmission of voice, data and digital information.

3. **Hoteling**: It is an on-site AWA where workspace is reserved on a first call basis(Gilleard and Rees, 1998) It is similar to both free address, which is unassigned workstations available on a first-come, first served basis and hot desking, which is reservation-less unassigned seating(US GSA, 2009).

4. **Shared office:** It is an on-site AWA where workplaces are assigned to two or more employees (Van Meel, 2000). This is similar to desk sharing, in which two or more employees share the same workstation in a typically pre-arranged manner that allows each of the employees to have sole access to the specified workstation on given days while the others involved in the sharing arrangement work elsewhere (US GSA, 2009).

5. **Group address:** It is an on-site AWA that is designated for group or team work space for a specified period of time (Gilleard and Rees, 1998). A group address is sometimes called a project team environment where flexible work areas are designed to support work teams. This type is an enclosed space designed to accommodate 4-12 workplaces (Van Meel, 2000).

6. **Satellite office:** It is an off-site AWA where office is located in close proximity to a customer or supplier. Satellite office provides ICT and administrative support like corporate office (Fritz et. al, 1994).

7. **Home office**: It is an off-site AWA where all the work is performed at home. It is interchangeably referred to as WAH (work at home), WFH (work from home), teleworking or telecommuting (Stevens and Szajna, 1998)

8. **Virtual office**: It is an off-site AWA where, by using ICT capabilities, workers conduct work anywhere, such as hotel rooms, airports, airplanes, or automobiles. Employees have freedom to office anywhere through the use of portable technology. The actual physical locations of the employees working in a virtual office can be temporary or permanent and can be nearly anywhere. In this research, a virtual office is categorized as an off-site type (US GSA, 2009).

APPENDIX B: LITERATURE REVIEW TABLE

Literature review table: Issues discussed																																					
				Appropriateness																												Challenges							
				Organizational characteristic					Work								Employee								Supports(facilities) issues				Managerial issues							
Number	Author(s)	Year	Method	Support	Fairness	Trust	Independency	Structure/size	Type	Process	Autonomy	Concentration	Deliverables	Physical presence	Knowledge work in nature	Traveling needs	Preference	Sufficiency	Effectiveness	Communication	Familiarity	Experience with AWA	Adaptability	Relationship	ICT	Premises supports	Business support services	Process administration	Result based Performance evaluation	Supervision	Coordination	Policy/guideline	Learning opportunities	Identity maintenance				
1	Ford & McLaughlin	1995	Survey	1	1	1											1	1	1	1		1			1		1											
2	Gupta et al.	1995	Survey						1	1															1													
3	Korzeniowski	1995	Case study	1	1	1								1											1													
4	Ruppel & Harrington	1995	Survey	1			1		1																				1		1	1					
5	Bui et. al	1996		1	1	1			1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1				
6	Fritz et al.	1996	Survey & Interviews	1	1		1		1	1	1	1	1	1			1	1			1	1	1	1	1			1		1	1	1	1	1			
7	Higa et. al	1996	Case study	1	1	1		1									1			1	1	1			1				1	1	1	1		1			
8	Lewis	1996	Case study	1	1	1			1	1							1				1	1			1												
9	McGonegle	1996	Case study	1		1	1										1																				
10	Pontell et al.	1996	Case study	1													1								1												
11	Raghuram et al.	1996	Interviews	1	1	1			1	1	1	1	1				1	1	1		1	1															
12	Rognes et al.	1996	Case study	1													1	1	1	1	1	1			1												
13	Watad & Disanzo	1996	Case study	1	1												1								1		1										
14	Shin et al	1997		1							1	1	1																								
15	Belanger & Collins	1998		1	1	1			1	1	1	1	1				1	1		1		1			1	1			1	1	1		1				
16	Fritz et al.	1998	Survey	1					1	1		1	1	1						1	1	1			1					1	1		1				
17	Higa & Wijayanayake	1998	Survey	1	1	1		1			1	1	1	1		1																					
18	Kurland & Bailey	1999	Case study & Interviews	1	1	1			1	1	1		1	1			1	1		1	1	1			1	1	1		1		1	1	1				
19	Bentley & Young	2000		1			1		1	1	1	1	1		1		1	1		1					1	1	1	1	1	1	1			1			
20	Cascio	2000	Case study	1	1	1			1	1	1	1	1	1			1	1	1	1	1	1			1	1	1		1	1	1	1					
21	DeMarie & Hitt	2000		1		1	1	1	1						1		1	1			1		1	1	1						1		1				
22	Gallagher & Watchman	2000	Case study	1				1	1									1			1		1									1	1		1		
23	Gupta et al.	2000	Survey	1	1	1		1	1	1	1	1	1	1			1	1	1	1	1				1							1					
24	Lim & Teo	2000	Survey	1		1	1		1	1							1	1		1				1	1	1	1	1	1	1							
25	Lupton & Haynes	2000	Survey	1	1	1	1	1									1		1						1						1						

APPENDIX B: LITERATURE REVIEW TABLE CONTINUED

Literature review table: Issues discussed																																					
Number	Author(s)	Year	Method	Appropriateness																											Challenges							
				Organizational characteristic					Work								Employee								Supports(facilities) issues				Managerial issues							
				Support	Fairness	Trust	Independency	Structure/size	Type	Process	Autonomy	Concentration	Deliverables	Physical presence	Knowledge work in nature	Traveling needs	Preference	Sufficiency	Effectiveness	Communication	Familiarity	Experience with AWA	Adaptability	Relationship	ICT	Premises supports	Business support services	Process administration	Result based Performance evaluation	Supervision	Coordination	Policy/guideline	Learning opportunities	Identity maintenance					
26	Miller & Cardy	2000		1	1				1	1	1				1		1	1				1	1		1	1	1		1	1	1					
27	Shin et al	2000		1	1	1		1	1	1	1						1		1						1				1		1					
28	Vega & Brenan	2000							1	1	1		1				1		1						1			1	1	1	1		1			
29	Ilozor et. al	2001	Survey	1	1				1				1							1					1	1	1		1	1	1	1	1			
30	MacDermid et. al	2001	Interviews	1	1	1			1	1	1		1																1	1	1	1	1			
31	Perry et. al	2001	Interviews	1					1	1						1				1					1					1	1					
32	Staples	2001	Interviews & survey	1	1	1														1		1		1	1					1	1					
33	Bailey & Kurland	2002		1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1			1	1	1	1	1			
34	Cooper & Kurland	2002	Interviews	1	1	1			1	1							1	1				1	1		1	1	1	1			1		1	1			
35	Haines et. al	2002	Survey	1					1	1						1	1	1	1						1		1		1	1	1			1			
36	Harrison	2002		1		1		1	1					1	1		1	1	1						1	1	1		1		1	1	1				
37	Karnowski and White	2002		1	1	1		1																	1	1	1			1	1						
38	Kayworth & Leidner	2002	Field experiment	1	1	1			1	1			1						1	1										1	1						
39	Tietze	2002	Case study			1			1		1	1					1	1							1	1										1	
40	Dimitrova	2003	Interviews	1	1				1	1	1		1		1		1	1		1	1	1			1				1	1	1	1	1			
41	Gibson	2003		1	1	1																			1	1			1								
42	Gilleard & Tarcisius	2003	Interviews & Survey	1					1	1			1	1										1		1	1	1	1		1	1					
43	Felstead et. al	2003	Case study & Interviews	1	1	1			1		1			1				1	1	1		1			1	1			1	1	1	1					
44	Hardill & Green	2003		1		1			1	1	1	1		1	1	1	1				1		1	1	1		1				1		1				
45	Higa & Shin	2003	Case study	1					1	1								1	1						1		1		1	1	1	1				
46																																					
47	Perez et. al	2003	Survey	1	1	1		1	1	1	1	1	1	1			1	1	1						1						1	1	1				
48	Pyoria	2003	Interviews & survey	1		1		1	1	1	1	1	1		1		1			1				1	1				1	1	1		1	1			

APPENDIX B: LITERATURE REVIEW TABLE CONTINUED

Literature review table: Issues discussed																																			
				Appropriateness																										Challenges					
				Organizational characteristic					Work								Employee								Supports(facilities) issues				Managerial issues					
Number	Author(s)	Year	Method	Support	Fairness	Trust	Independency	Structure/size	Type	Process	Autonomy	Concentration	Deliverables	Physical presence	Knowledge work in nature	Traveling needs	Preference	Sufficiency	Effectiveness	Communication	Familiarity	Experience with AWA	Adaptability	Relationship	ICT	Premises supports	Business support services	Process administration	Result based Performance evaluation	Supervision	Coordination	Policy/guideline	Learning opportunities	Identity maintenance
49	Siha & Monroe	2006		1	1	1	1	1	1	1	1	1	1	1	1		1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
50	Sullivan	2003		1				1	1																1										
51	Watad & Will	2003	Survey	1	1	1		1	1	1			1				1	1	1					1	1	1	1		1	1	1		1		
52	Harrison et. al	2004		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
53	Peters et. al	2004	Survey	1	1	1	1		1	1	1	1	1	1			1	1							1	1	1				1				
54	Sia et. al.	2004	Survey	1	1	1	1		1	1								1	1	1					1	1	1				1		1		
55	Swan et al	2004	Case study	1		1	1		1	1															1	1	1		1		1				
56	Clear & Dickson	2005	Case study	1					1		1														1				1	1	1		1		
57	Haddon & Brynin	2005	Survey						1			1		1							1	1			1										
58	Kowalski & Swanson	2005		1		1			1								1		1	1					1	1	1						1		
59	Ndubisi & Kahraman	2005	Survey	1					1	1	1	1		1			1	1		1					1	1	1		1	1	1				
60	Dickon & Clear	2006	Survey	1	1	1					1											1			1	1	1		1	1				1	
61	Hassanain	2006		1							1														1	1	1				1				
62	Kelly & Kalev	2006	Interviews	1		1	1		1	1								1	1	1	1	1	1						1	1	1	1			
63	Roitz and Jackson	2006	Case study	1	1	1			1	1	1				1		1	1	1						1		1		1	1	1	1	1	1	1
64	Campbell & McDonald	2007		1		1								1			1	1							1				1	1	1	1			
65	Lee et. al	2007	Interviews & survey						1			1		1		1					1	1			1										
66	Maxwell et. al	2007	Interviews & survey				1	1				1					1				1				1				1	1	1	1	1		
67	Roper & Kim	2007		1	1	1			1	1	1	1	1	1			1	1	1						1	1	1		1	1	1				
68	Venezia et. al	2007	Survey	1					1	1							1								1	1	1			1	1		1		
69	Hoang et. al.	2008	Survey	1	1	1			1	1							1	1		1					1	1			1	1	1	1			1
70	Martinez-Sanchez et.al	2008	Survey	1					1	1	1	1	1	1			1	1	1	1	1	1			1	1	1		1		1	1	1		
71	Origo and Pagani	2008	Survey	1					1	1	1							1	1	1													1		
72	Roper & Kim	2008		1	1	1			1	1		1	1	1			1	1							1	1	1		1	1	1				
Total frequency of citations				65	37	43	14	17	54	42	32	25	27	24	11	8	44	37	25	28	22	24	11	10	61	31	32	9	35	35	52	26	27	15	
Low: 1-20, Med: 21-40, High: 41+				High	Med	High	Low	Low	High	High	Med	Med	Med	Med	Low	Low	High	Med	Med	Med	Med	Med	Low	Low	High	Med	Med	Low	Med	Med	High	Med	Med	Low	

APPENDIX C: DATA COLLECTED

Organization	Location	Industry	Job type	Position	case date	Retention/attraction of skilled employees	Reduced office space costs	Improved productivity	Reduced turnover and absenteeism	Improved customer satisfaction	Reduced traffic congestion and environmental impacts	Employment opportunities for ageing and handicapped people and employees' work-life balance	FWA is supported at all levels of organization	The degree of equal promotional opportunity for distributed workers	The level of trust between managers and their employees	The level of interaction/communication needed to perform the work	The degree of sequential work process vs. reciprocal process (The degree of transactional vs. open ended	The degree of autonomy for work(work scheduling, decision prerogatives, etc)	The level of clarity of defined deliverables	Required physical presence at the office for work to be able to access specific technology, equipment or live	Employees' level of preference for FWA	Employees' level of self-sufficiency to work	Employees' level of familiarity with ICT	Employees' work experiences with flexible work style	The provision of ICT support	The level of premise supports	The level of business support services	Results-based performance evaluation method in place	Virtual teamwork in practice within the organization	Clear policy/guideline provision for FWA	Type selected	Success level
						a1	a2	a3	a4	a5	a6	a7	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18	Y1	Y2
A	US	Telecom	Finance	Supervisor	2006	1	1	0	0	0	1	0	3	2	3	2	3	2	2	1	1	3	2	1	2	1	2	2	2	1	1	3
B	US	Telecom	Finance	Senior manager	2006	1	1	0	0	0	1	0	2	1	2	2	1	2	1	1	1	1	1	2	1	1	2	1	1	1	1	1
C	US	Networking	Finance	Middle manager	on-going	1	1	1	0	0	0	0	3	3	3	3	2	3	3	2	3	3	3	3	3	3	2	3	3	3	1	3
G	US	Telecom	Sales	Middle manager	2007	1	1	0	0	0	0	1	2	2	2	2	2	1	1	1	1	2	2	2	2	2	2	2	2	1	1	2
H	US	Computer	Customer service	Middle manager	2008	1	1	1	0	0	0	0	2	3	2	3	3	2	1	2	2	1	2	2	3	2	2	2	2	1	1	3
I	Korea	Consumer Electronic	Finance	Middle manager	2008	1	1	0	0	0	0	1	2	1	1	1	1	1	1	1	1	1	1	2	1	2	1	2	1	1	1	1
L	Taiwan	IT	Consulting	Supervisor	on-going	1	1	1	0	0	0	0	2	2	2	2	2	2	2	2	2	2	2	1	2	3	3	2	2	2	1	3
M	Taiwan	IT	IT staff	Supervisor	on-going	1	1	0	0	0	0	1	1	2	1	2	2	2	1	2	1	2	2	1	2	2	1	1	1	1	1	1
N	Taiwan	Technology	IT staff	Middle manager	on-going	0	1	1	0	0	1	0	1	3	2	2	2	1	2	2	1	1	2	1	1	2	2	1	2	1	1	2
Q	Japan	Technology	Customer service	Middle manager	2007	0	1	1	0	0	0	1	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	1	1	3
Q	Finland	Telecom	Research	Senior manager	on-going	1	1	0	0	0	0	1	2	3	2	3	3	3	3	1	2	3	3	1	2	3	2	3	2	1	1	1
A	US	Telecom	Sales	Supervisor	2007	0	0	1	1	1	0	0	2	2	2	3	3	2	1	3	1	1	1	1	2	2	2	1	1	1	2	3
B	US	Telecom	Finance	Senior manager	2005	0	1	1	1	0	0	0	2	2	2	3	3	2	2	3	2	2	2	1	3	2	2	1	1	1	2	3
D	US	Computer	Research	Director	2007	0	0	1	1	1	0	0	2	2	2	2	3	2	2	3	1	2	1	2	3	2	2	1	1	2	2	3
E	US	Technology	Consulting	Middle manager	on-going	0	1	1	1	0	0	0	2	2	1	2	2	1	2	2	3	2	2	1	2	2	2	3	1	1	2	1
G	US	Telecom	IT staff	Middle manager	2008	0	1	1	1	0	0	0	2	2	2	3	3	2	2	3	2	2	2	1	3	2	2	2	1	1	2	3
K	Korea	Telecom	HR	Middle manager	2007	0	0	1	1	1	0	0	2	2	2	2	3	1	2	2	1	1	1	1	2	2	2	1	1	1	2	2
K	Korea	Telecom	HR	Middle manager	2008	0	0	1	1	1	0	0	2	2	2	2	3	2	2	3	1	1	1	2	3	2	2	1	1	1	2	3
R	Finland	Telecom	Research	Senior manager	on-going	1	1	0	0	0	0	1	2	3	2	3	3	2	2	1	2	2	2	1	2	3	2	3	2	1	2	1
B	US	Telecom	Customer service	Senior manager	2006	0	1	0	0	0	1	1	3	2	2	2	2	1	3	1	2	2	2	3	3	3	2	2	2	3	3	3
D	US	Computer	Sales	Director	2008	0	1	0	0	0	1	1	2	2	1	2	2	2	3	2	2	2	1	1	2	2	2	1	1	1	3	2
D	US	Computer	Sales	Director	2007	0	1	0	0	0	1	1	2	3	2	2	2	2	3	2	2	1	2	1	2	3	2	2	1	1	3	2
E	US	Technology	Consulting	Middle manager	on-going	1	1	1	0	0	0	0	2	2	1	2	2	2	2	2	3	2	3	2	2	1	2	3	2	2	3	2
G	US	Telecom	IT staff	Middle manager	2008	0	1	1	0	0	0	1	3	2	2	2	2	2	3	1	2	2	2	2	3	3	3	2	2	2	3	3
S	Korea	Telecom	Clerical	Middle manager	on-going	1	1	1	0	0	0	0	2	2	1	2	2	2	2	2	1	2	2	1	2	2	1	2	1	1	3	2
J	Korea	Technology	Research	Middle manager	2008	1	1	1	0	0	0	0	1	1	1	2	2	1	1	2	1	2	2	1	2	2	1	1	1	1	3	1
J	Korea	Technology	Research	Middle manager	on-going	1	1	1	0	0	0	0	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	3	2
Q	Japan	Technology	HR	Middle manager	2008	1	1	0	0	0	0	1	1	1	2	2	2	2	1	2	1	2	2	1	1	2	2	1	2	1	3	2
A	US	Telecom	Finance	Supervisor	2006	1	1	0	0	0	1	0	3	2	3	2	2	2	3	2	2	2	3	1	2	2	2	3	2	2	4	3
A	US	Telecom	Sales	Supervisor	2007	0	1	0	0	1	0	1	2	2	2	2	2	3	3	2	2	2	2	2	2	2	2	3	2	2	4	3
F	US	Engineering	Sales	Senior manager	2008	0	1	1	0	1	0	0	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	4	2
I	Korea	Consumer Electronic	Sales	Middle manager	2008	0	0	1	1	1	0	0	2	2	2	2	3	3	2	3	2	3	2	3	3	3	3	2	2	3	4	3
I	Korea	Consumer Electronic	Sales	Middle manager	2008	0	0	1	1	1	0	0	3	3	3	3	3	2	2	3	3	3	3	3	3	3	3	3	3	2	4	3
I	Korea	Consumer Electronic	Finance	Middle manager	on-going	0	0	1	1	1	0	0	2	1	2	1	2	1	1	2	1	1	1	1	2	1	2	2	1	1	4	1
I	Korea	Consumer Electronic	Sales	Middle manager	2008	0	0	1	1	1	0	0	2	3	2	2	2	3	3	2	3	2	3	2	2	3	2	2	2	3	4	3
L	Taiwan	IT	IT staff	Supervisor	on-going	1	0	1	0	1	0	0	2	3	2	3	2	2	2	3	3	3	3	2	3	3	3	3	2	2	4	3
O	Taiwan	IT	Consulting	Middle manager	on-going	0	0	1	1	1	0	0	2	2	2	2	2	3	2	2	3	2	2	3	3	3	3	2	3	2	4	3
P	Taiwan	Consumer Electronic	Finance	Middle manager	on-going	1	1	0	0	0	1	0	1	2	1	2	1	1	1	1	1	2	1	1	1	2	1	2	1	1	4	1

APPENDIX C: DATA COLLECTED CONTINUED

Organization	Location	Industry	Job type	Position	case date	Retention/attraction of skilled employees	Reduced office space costs	Improved productivity	Reduced turnover and absenteeism	Improved customer satisfaction	Reduced traffic congestion and environmental impacts	Employment opportunities for ageing and handicapped people and employees' work-life balance	FWA is supported at all levels of organization	The degree of equal promotional opportunity for distributed workers	The level of trust between managers and their employees	The level of interaction/communication needed to perform the work	The degree of sequetial work process vs reciprocal process (The degree of transactional vs. open ended)	The degree of autonomy for work(work scheduling, decision prerogatives, etc)	The level of clarity of defined deliverables	Required physical presence at the office for work to be able to access specific technology, equipment or live	Employees' level of preference for FWA	Employees' level of self-sufficiency to work	Employees' level of familiarity with ICT	Employees' work experiences with flexible work style	The provision of ICT support	The level of premise supports	The level of business support services	Results-based performance evaluation method in place	Virtual teamwork in practice within the organization	Clear policy/guideline provision for FWA	Type selected	Success level
						a1	a2	a3	a4	a5	a6	a7	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18	Y1	Y2
Q	Japan	Technology	Customer service	Middle manager	2007	1	0	1	0	0	0	1	2	2	3	1	1	3	3	1	3	3	2	3	2	2	3	2	2	3	4	3
Q	Japan	Technology	Customer service	Middle manager	2008	1	0	1	0	0	0	1	1	2	2	3	1	2	1	3	1	2	1	1	1	1	1	1	2	1	4	1
Q	Japan	Technology	HR	Middle manager	On-going	1	0	1	0	1	0	0	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2	2	1	4	2
B	US	Telecom	Clerical	Senior manager	2006	1	1	1	0	0	0	0	2	1	1	2	2	2	1	2	2	2	1	1	1	2	1	2	1	2	5	1
B	US	Telecom	Customer service	Senior manager	2006	1	0	1	1	0	0	0	3	3	3	1	1	3	3	1	3	3	3	2	3	2	3	3	3	3	5	3
B	US	Telecom	Customer service	Senior manager	2005	1	0	1	1	0	0	0	2	3	2	1	1	3	3	1	3	3	2	3	2	2	3	3	2	3	5	3
C	US	Networking	Clerical	Middle manager	2007	0	1	1	0	0	0	1	3	3	3	2	3	3	2	1	2	2	3	2	3	1	2	3	3	3	5	2
C	US	Networking	Clerical	Middle manager	2008	0	1	1	0	0	0	1	3	3	3	2	3	3	3	1	3	3	3	3	3	1	3	3	3	3	5	3
D	US	Computer	Research	Director	on-going	0	1	1	0	0	0	1	3	2	2	1	1	2	3	1	3	2	2	3	3	1	3	2	3	3	5	3
F	US	Engineering	Research	Senior manager	2008	1	1	1	0	0	0	0	3	2	2	2	3	3	2	1	3	2	2	2	3	1	2	3	2	3	5	2
G	US	Telecom	IT staff	Middle manager	2008	0	1	1	0	0	0	1	3	2	2	2	2	3	2	1	3	2	3	2	3	2	3	3	2	3	5	3
H	US	Computer	Research	Middle manager	2008	1	1	0	0	0	1	0	2	3	2	1	2	3	2	1	3	2	3	2	3	2	3	2	3	3	5	3
H	US	Computer	Clerical	Middle manager	2008	1	1	0	0	0	1	0	2	3	2	1	3	3	2	1	3	2	3	2	3	2	3	2	3	3	5	3
M	Taiwan	IT	Consulting	Supervisor	on-going	0	1	1	0	0	0	1	1	2	1	2	2	2	2	2	2	2	1	1	2	1	1	1	2	2	5	1
A	US	Telecom	Sales	Supervisor	2008	0	1	1	0	1	0	1	2	2	2	2	2	2	1	2	3	2	2	2	2	2	3	2	2	2	6	2
B	US	Telecom	Finance	Senior manager	2005	0	1	1	0	1	0	0	3	3	3	2	1	2	2	1	3	2	2	2	3	2	2	2	2	2	6	3
C	US	Networking	Sales	Middle manager	2007	0	1	1	0	0	1	0	3	3	3	2	3	3	3	1	3	3	3	3	3	1	3	3	3	3	6	3
C	US	Networking	Sales	Middle manager	2008	0	1	1	0	0	1	0	3	3	3	2	3	3	3	1	3	3	3	3	3	1	3	3	3	3	6	3
D	US	Computer	Sales	Director	2008	1	1	1	0	0	0	0	2	2	2	1	2	2	1	2	3	2	2	2	3	1	2	3	2	2	6	2
E	US	Technology	Consulting	Middle manager	on-going	0	1	1	0	0	1	0	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	3	1	1	6	1
K	Korea	Telecom	Sales	Middle manager	2007	0	1	1	1	0	0	0	2	3	2	1	2	2	2	1	3	2	3	2	3	1	1	3	3	3	6	3
K	Korea	Telecom	Sales	Middle manager	on-going	0	1	1	0	1	0	0	3	3	2	1	1	3	3	1	3	3	3	3	3	2	2	3	3	3	6	3
K	Korea	Telecom	Sales	Middle manager	on-going	0	1	1	0	1	0	0	3	3	2	1	1	3	3	1	3	3	2	3	3	2	2	3	3	3	6	3
N	Taiwan	Technology	Consulting	Middle manager	on-going	0	1	1	0	1	0	0	2	2	2	2	2	1	1	2	3	2	2	2	2	2	3	2	2	6	6	2
R	Finland	Telecom	Sales	Senior manager	2008	0	1	1	0	1	0	0	2	3	2	2	2	2	2	2	2	3	2	2	1	1	2	3	2	1	6	2
R	Finland	Telecom	Sales	Senior manager	on-going	0	1	1	0	1	0	0	2	3	2	2	2	2	2	2	2	3	3	2	2	1	2	3	2	1	6	2

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